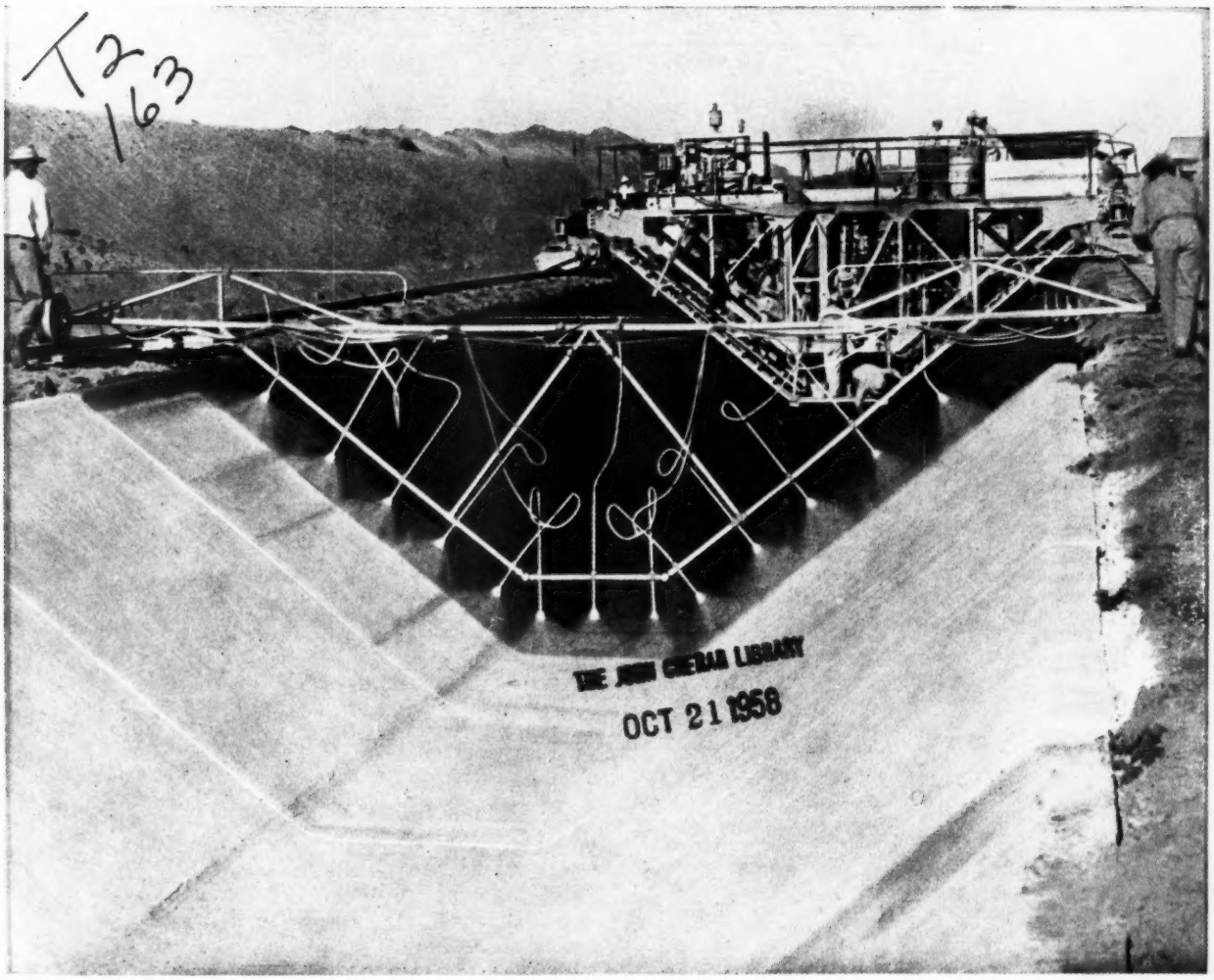
# INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

VOL. VIII. NO. 6 JUNE, 1958 RUPEES TWO



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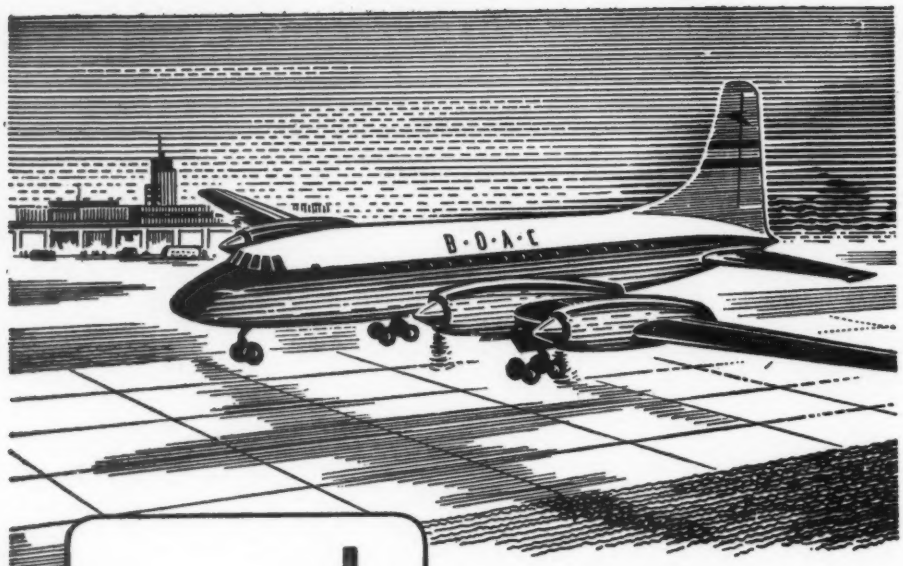


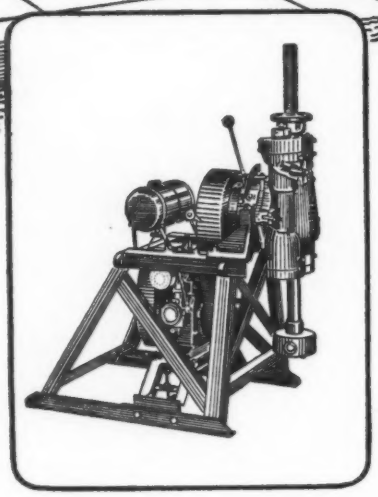

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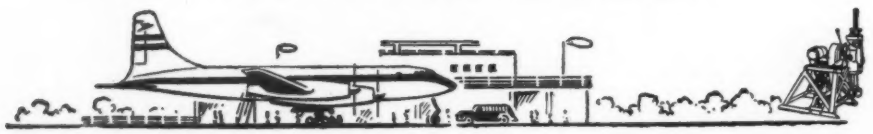

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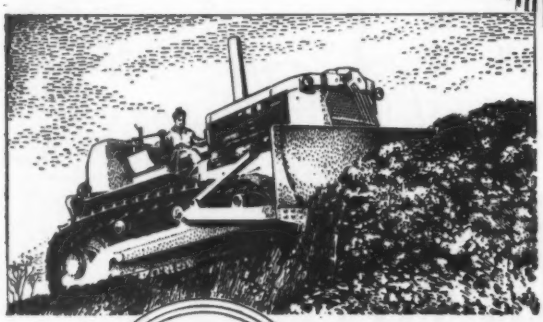

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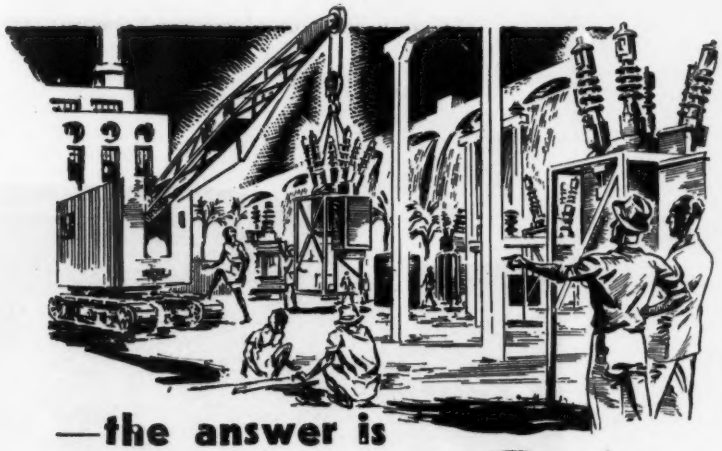
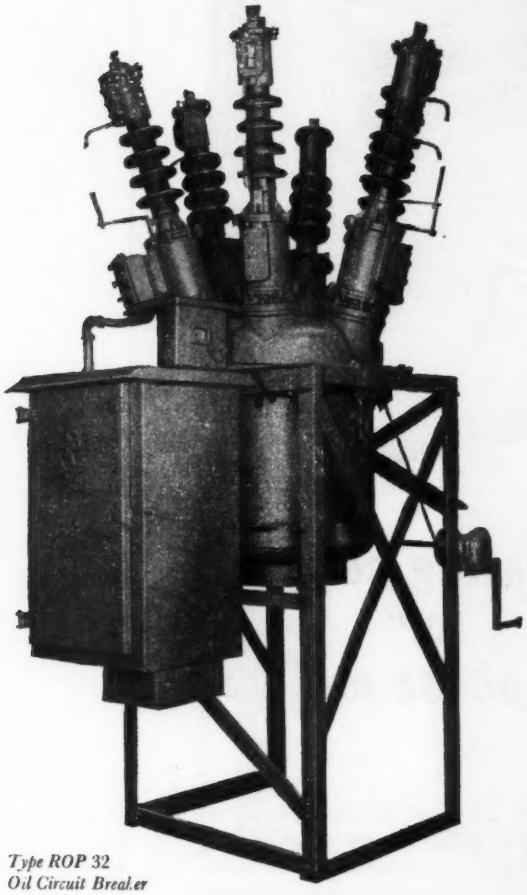


## —the answer is *Ferguson Pailin*

When the dam is built and the major constructional work completed the task of installing the electrical plant and the equipment must be undertaken.

Ferguson Pailin have supplied switchgear for indoor and outdoor stations, including major hydro-electric schemes the world over. 'F. P.' is synonymous with first-class design, manufacture and performance of this essential equipment, ranging from extra high voltage switchgear for main grid supply systems down to low voltage switchgear for industrial purposes.



*Type ROP 32*
*Oil Circuit Breaker*

*Two examples of 'Ferguson Pailin' switchgear, for varying duties, are illustrated here. They are :—*

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Wherever 22 kV or 33 kV outdoor oil circuit-breakers for breaking capacities up to 750 MVA are required the merits of the 'ROP 32' breaker should be considered.

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The circuit-breaker tank is of cylindrical shape and all three phases are brought into one tank, permitting the use of smaller framework thereby achieving compactness.

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'Ferguson Pailin' Type BV switchgear is of the completely enclosed metalclad type. It is constructed on the unit principle and can readily be extended by units of similar rating, or by metalclad oil switches.

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*A 'Ferguson Pailin' 3 kV (BV) switchboard installation at the South Fremantle Power Station of the State Electricity Commission of Western Australia.*

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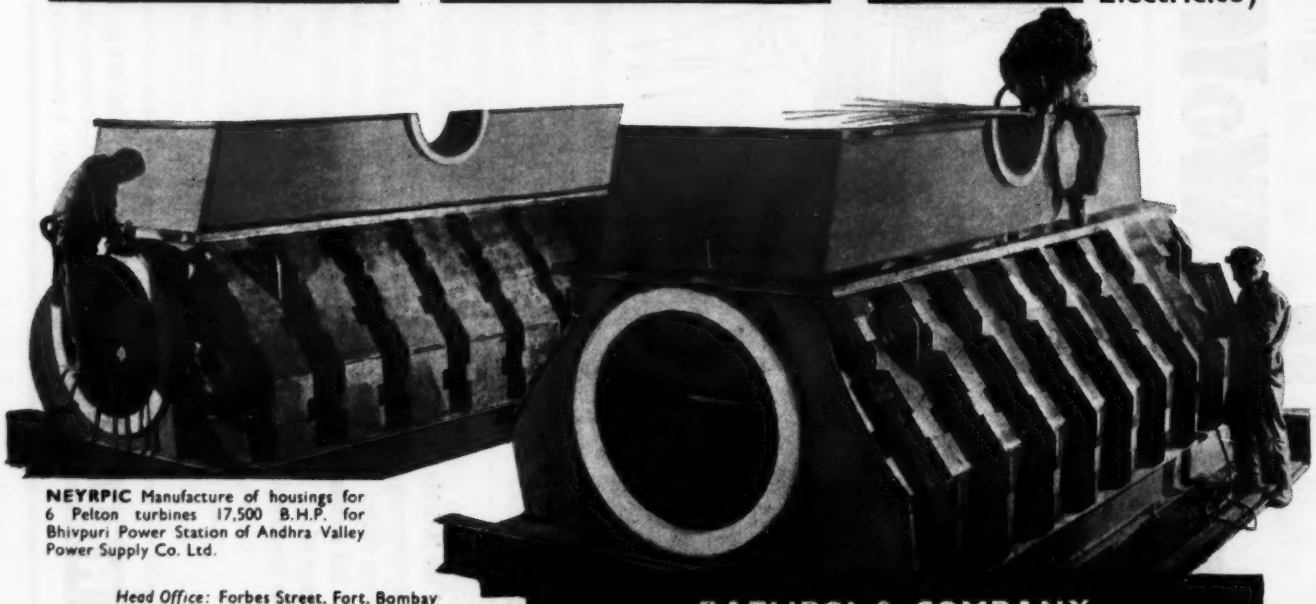

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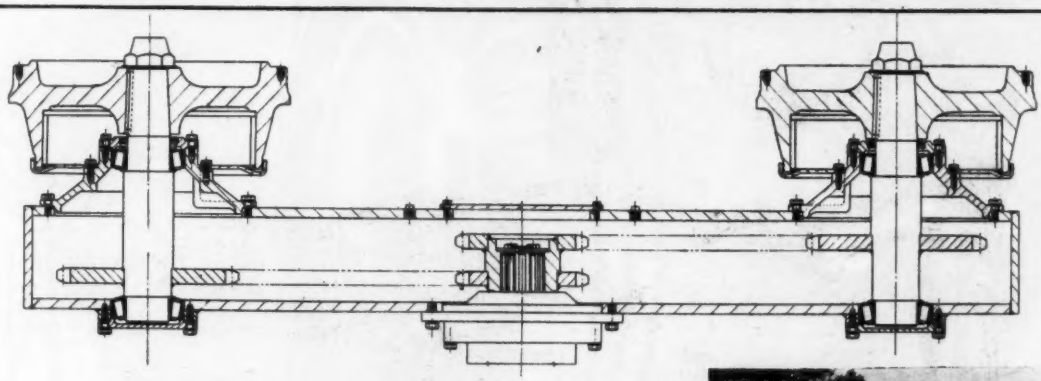

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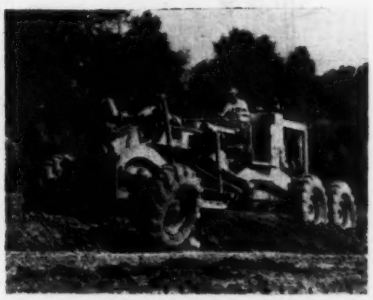

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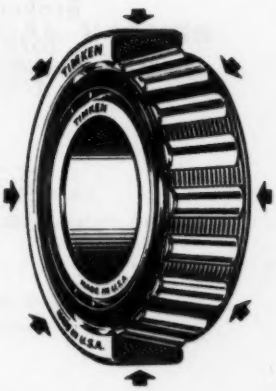


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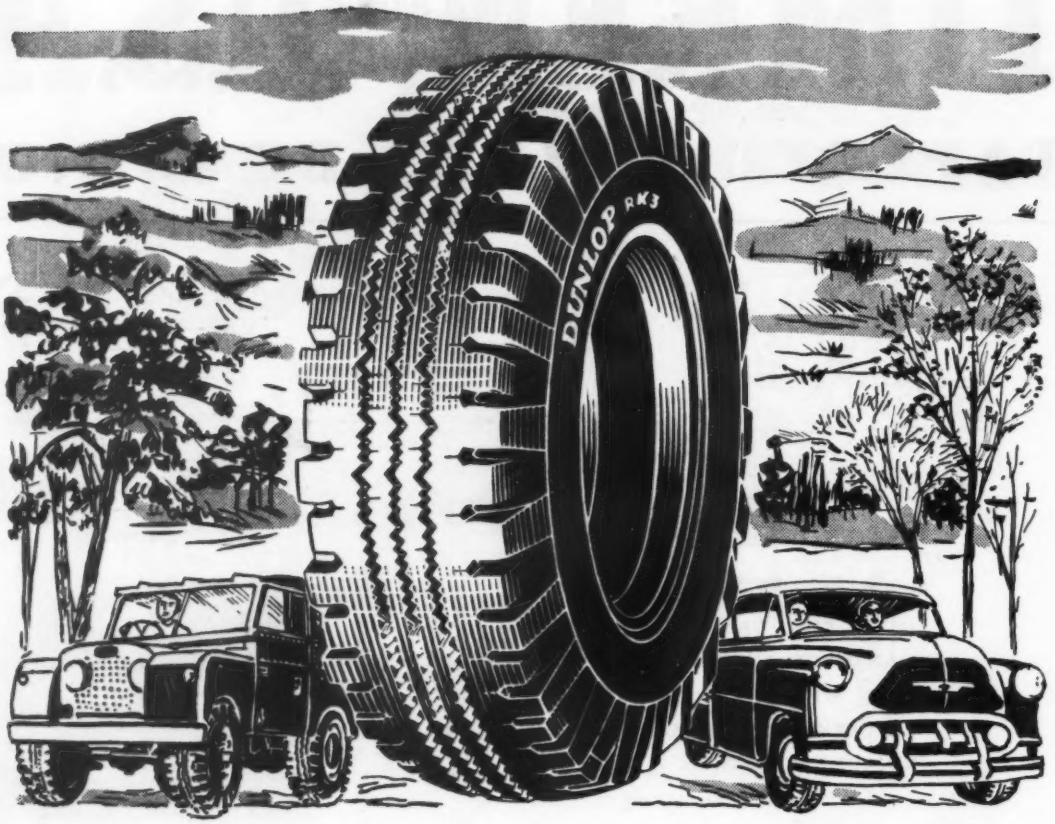


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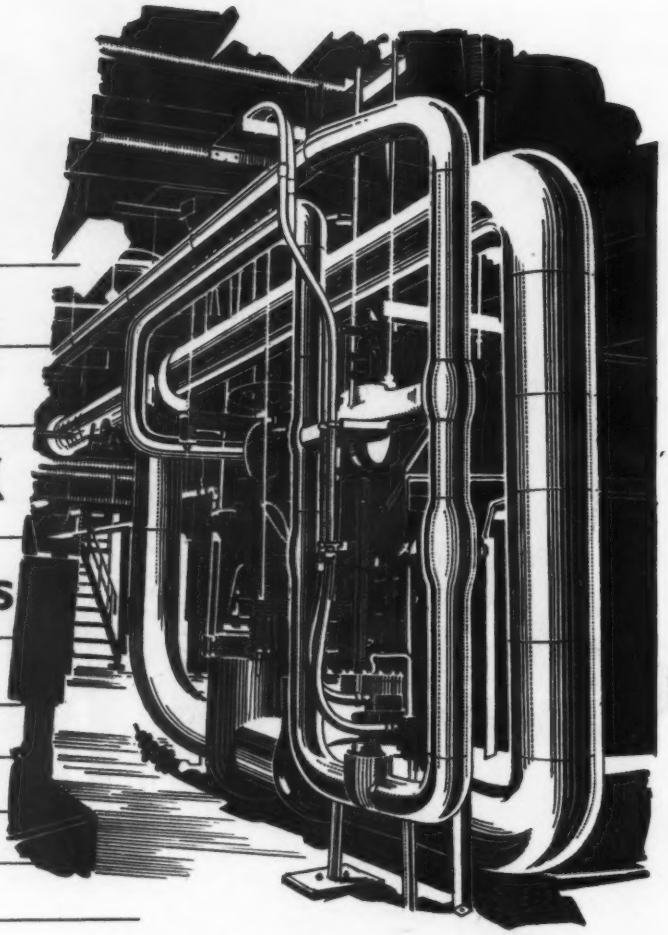

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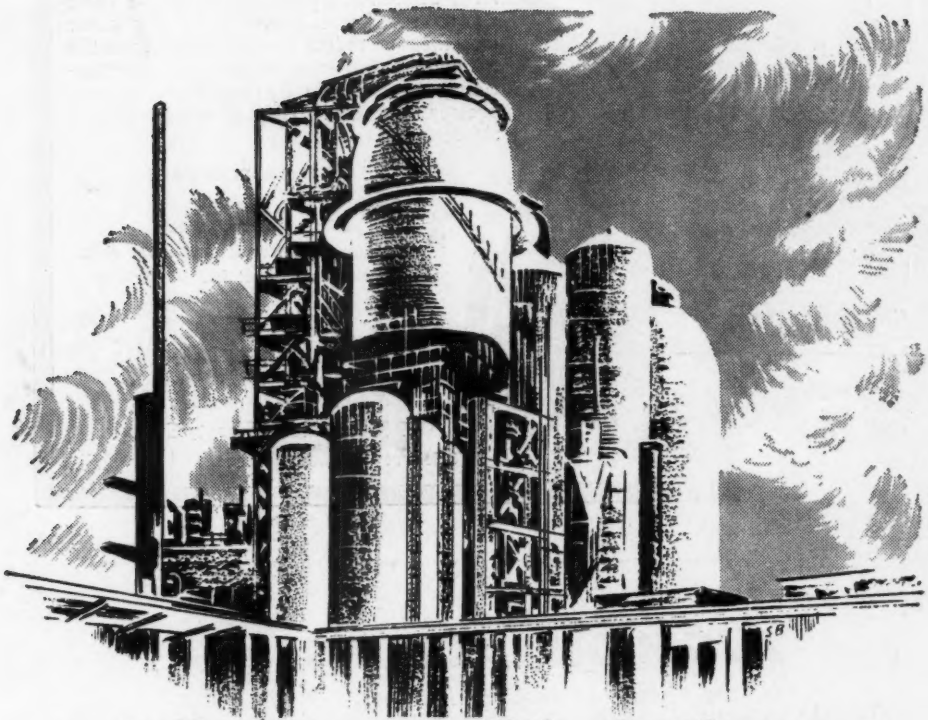

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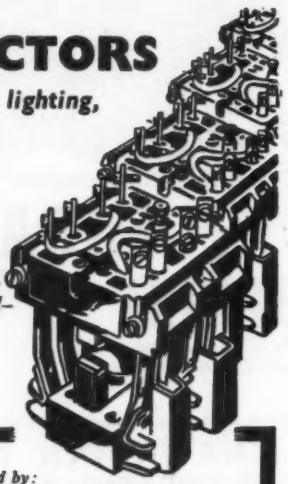

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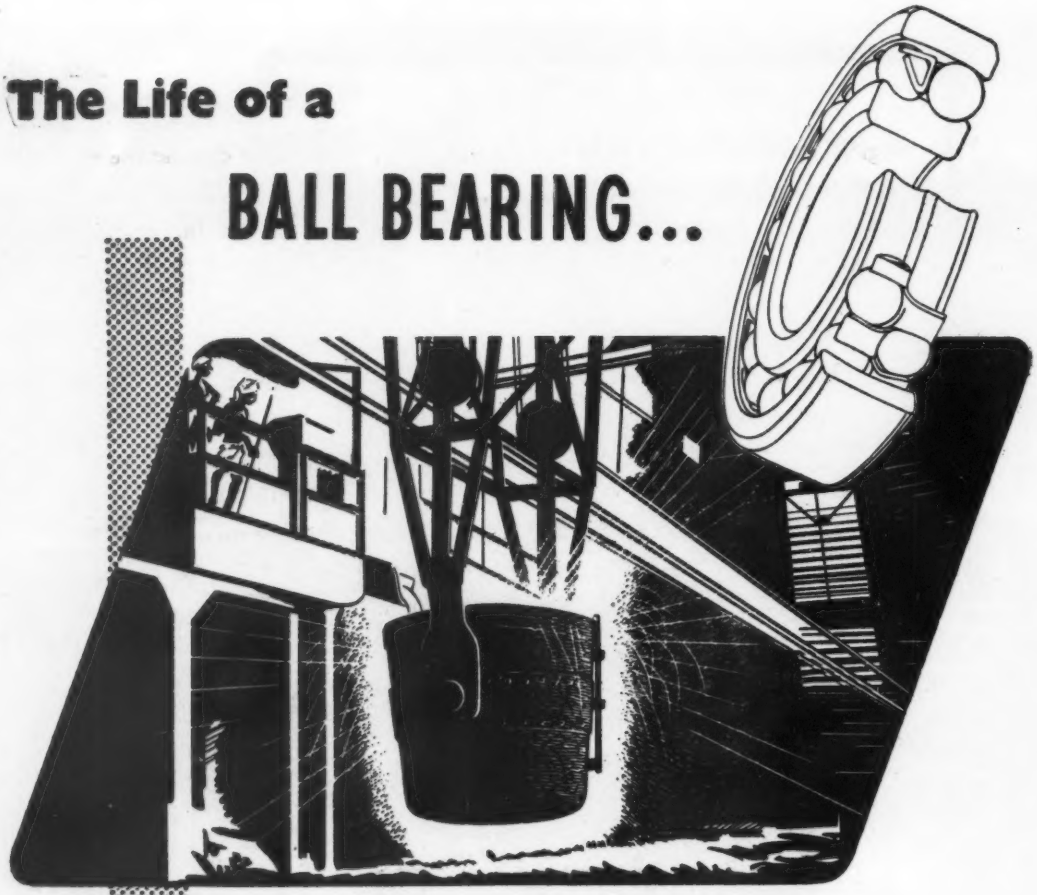

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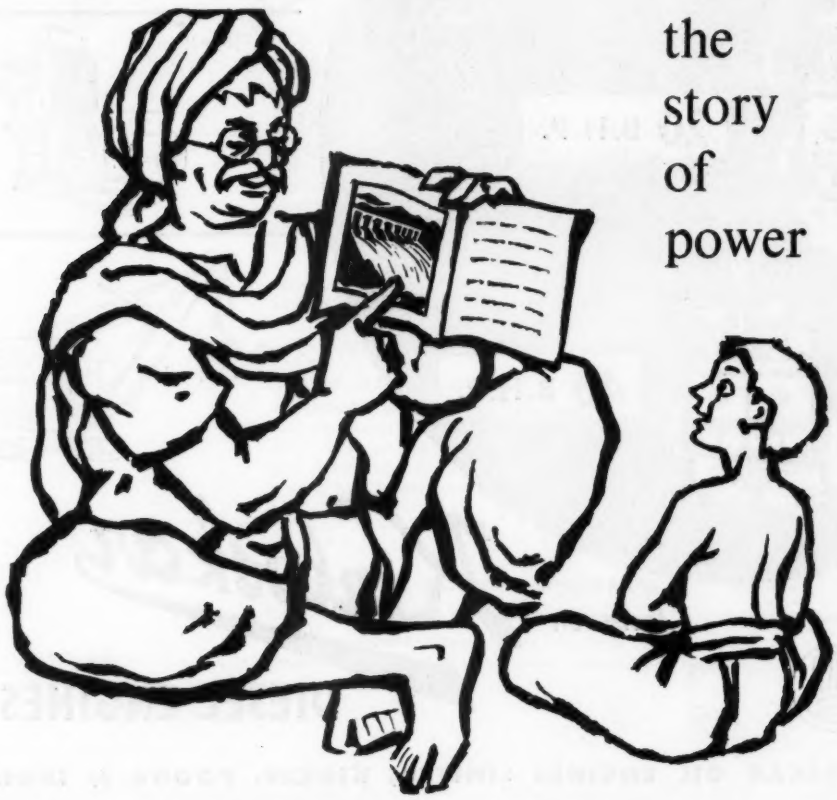

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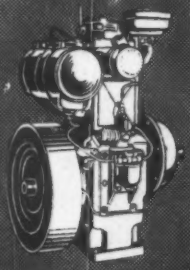

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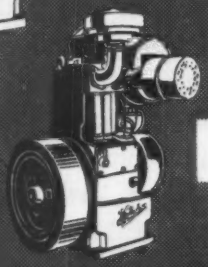

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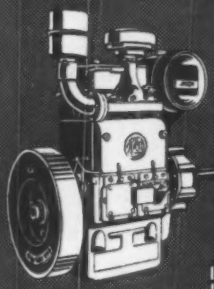

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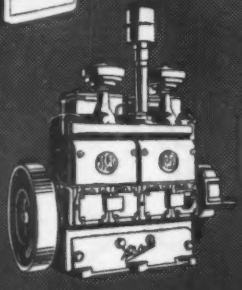

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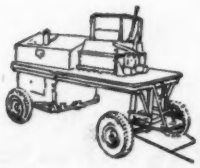

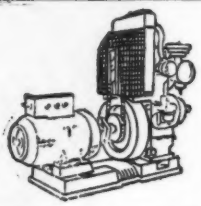

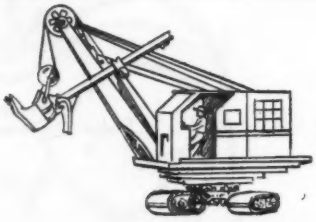

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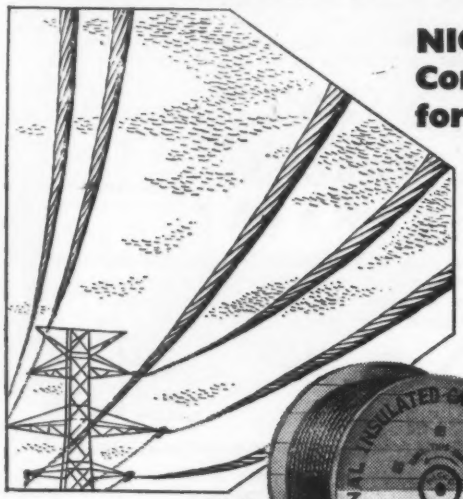

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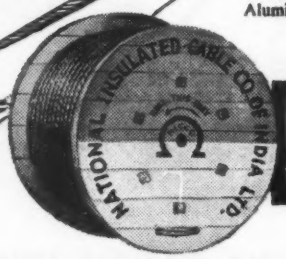


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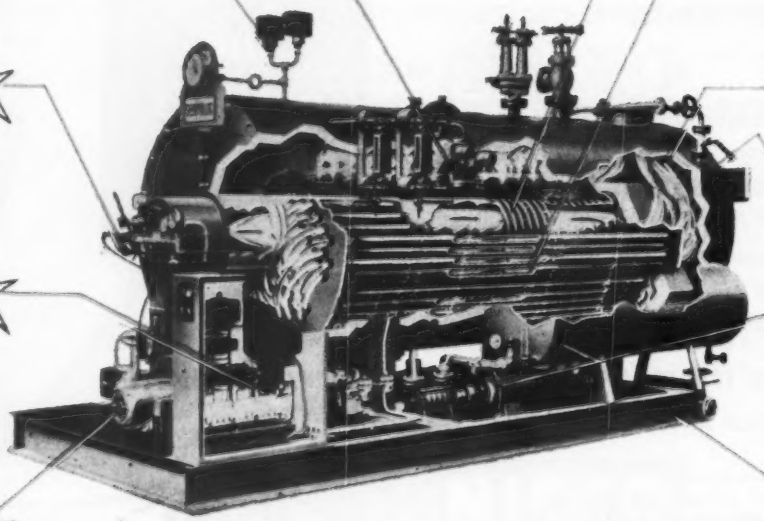

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Editor : K. K. Sinha — P. K. Menon : Mg. Editor

**VOL. VIII** — **JUNE 1958** — **NO. 6**


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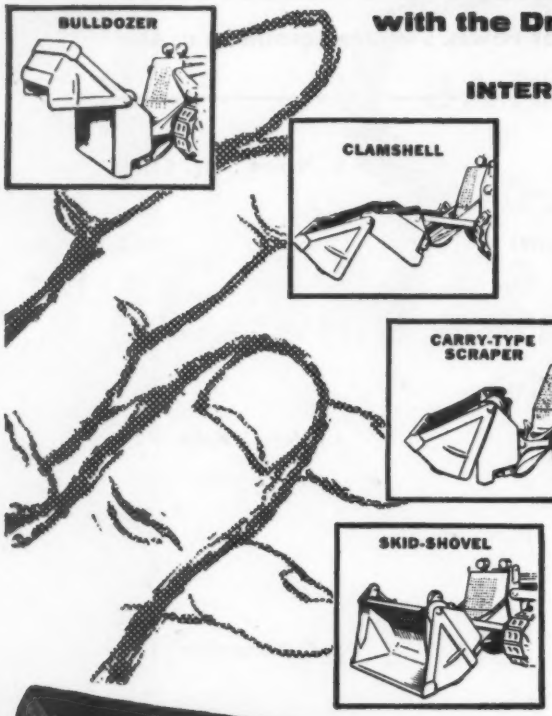


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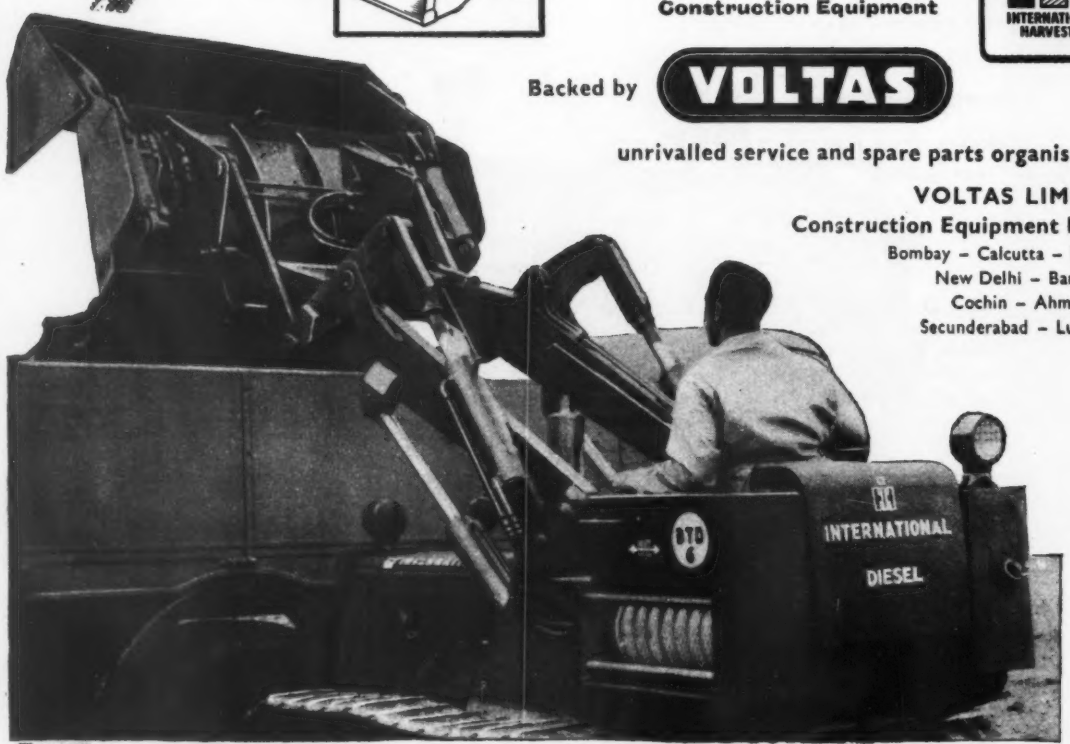



VOL.58.E

EVEREST

# Water Power Development in Africa

*Revolutionary changes are in the making as man moves to generate electricity from Africa's rivers. Industrialization will cost billions, but in Africa the incentives are high: minerals, open land, and two-fifths of the hydroelectric potential of the world.*

By ROBERT C. KEITH

Like a great overturned saucer, Africa south of the Sahara dips down to meet the sea only at the last moment. Inland, great rivers like the Congo flow uninterrupted and navigable for hundreds or even thousands of miles, only to have their quiet journey broken at the very end by the plunge through gorges and treacherous rapids. Herein lies one of the major reasons why exploration was difficult, why, although Portuguese navigators were able to chart the coastline in the early 1500's, much of the interior has become known to the outside world only in the past 75 years.

In charting Africa's river systems, David Livingston abhorred every discovery of waterfall or rapids, for it meant one more obstacle to the opening up of the continent. "No sooner do the rivers emerge from the higher lands than their utility is impaired by cataracts", he once wrote in dismay.

Today, it is soberly estimated that the same cataracts which troubled Livingston and helped keep Africa in isolation for centuries can be controlled by man to produce twice as much hydro-electric power as is potentially available from any other continent.

The electricity can be produced close at hand to some of the world's greatest mineral concentrations, bringing industry into the bush and ultimately leading to revolutionary social and economic change over large stretches of Africa.

At the present time, plans for harnessing Africa's waters are being studied closely by local governments, European metropoles and businessmen throughout the western world. There are many indications that the "break-through" period for developing the continent's hydroelectric potential is being witnessed now. "Some of the most far-reaching investment decisions being made these days are focussed on Africa," Fortune magazine reported last month. For Africa, the implications could be breathtaking.

**Gouina falls on the Senegal River, French West Africa**

**The motor road across the top of the Owen Falls dam at Jinja, Uganda.**

Along the Zambezi River dividing Northern and Southern Rhodesia, work is proceeding ahead of schedule on the $224 million Kariba project, partially financed by a World Bank loan of $80 million, which is the largest the bank has ever given for a single project. Kariba will power factories, cities and copper mills in the Central African Federation and its man-made lake will be the world's largest.

Thousands of miles across the continent, in Guinea. French West Africa, French, American, British and Swiss interests expect to begin construction this spring on a major project to harness the Konkoure River for the production of aluminium.

Southward down the coast, detailed plans have been drawn up for damming the Volta in Ghana. In the French Cameroons, France is enlarging the Edea works on the Sanaga River. Still farther south the French hope to create an industrial complex around the Sounda gorge on the Kouilou River in French Equatorial Africa. However, the prospects for the Volta and Kouilou schemes are by no means certain.

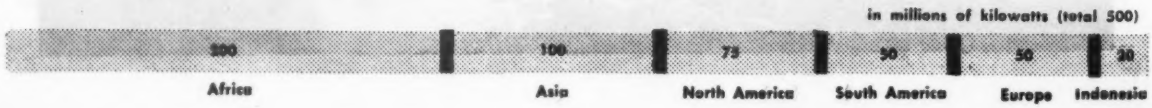
In Northeast Africa, hydrographic and aerial studies are being carried out with an eye to creating vast new control projects along the Nile.

Most staggering of all is the scheme contemplated for the Belgian Congo. Less than 100 miles from the coast, at a rapids known as Inga where the Congo River plunges 300 feet in a 15-mile "awesome span of sustained violence" Belgian authorities are hopeful of creating an African 'Ruhr". Plans to go ahead with preparatory work for the first stage were announced in Brussels November 13, following a meeting of the Council of Ministers presided over by King Baudouin himself. It is believed that Inga, if it ever reaches its full potential will be able to produce as much power as isnow consumed by the whole of Western Europe, and at the cheapest rate of any large installation in the world.

An American power expert, Walker Cisler, president of the Detroit Edison Company and advisor to President Eisenhower on energy problems, visited the Inga site in August and came away convinced it could help powerfully in bringig about a better distribution of the resources and population of the world.

But financial backing for a scheme as gigantic as Inga is hard to find unless it can be shown with certainty that industries will be willing to move in and use its power, and it is toward this problem that Belgium is now directing much of her attention.

One handicap at the moment is a world oversupply of aluminum and other metals which Inga power would help produce. Ghana is now encountering difficulty in finding takers for her billion dollar Volta River aluminum scheme, and is discovering that



unless use of the electricity can be guaranteed, agencies such as the World Bank are unwilling to capitalize dam construction.

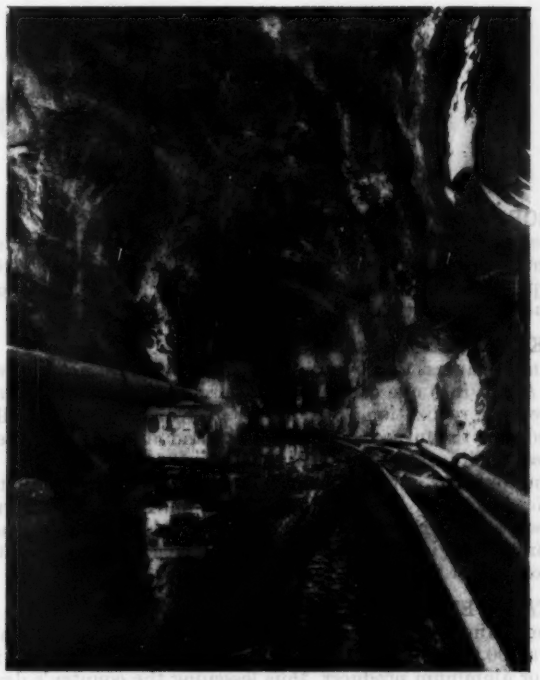
Total realization of the Inga industrial complex, which will require a monumental $3 billion investment over a 30 year period, is probably no more firm at the present time. According to available information, the Belgians themselves expect to provide $308 million reportedly needed for the first the stage, which involves water diversion rather than storage behind a large dam. This stage is said to offer a potential of 1.57 million kilowatt hours yearly, compared with an estimated production of 25 million kilowatt hours (10 times that of Grand Coulee) if the full scheme is completed.

In order to finance the later stages of Inga, Belgium has put aside past objections to foreign capital entering the Congo and is now encouraging American participation. In September, Edgar Van der Straeten, vice-governor of the giant Congo holding company, Societe Generale de Belgique, said in the course of a New York speech that foreign capital "will find all desirable guarantees in the social climate prevailing in the Congo as well as in its open door policy which places all countries on an equal commercial footing". For the Belgians, who until now have been responsible for 90 per cent of Congo investment, compared with the less than I per cent which comes from the U. S.. This was a significant decision, reached only after Minister of the Colonies Auguste Buisseret's insistence last year that Congo investment needs had gone beyond Belgium's capacity.

Injection of hundreds of millions of dollars and creation of major new industries are sure to bring problems as well as advantages to African countries which have been essentially agricultural for centuries and are in many cases under-developed and sparsely-populated. New towns will arise and Africans will migrate to them in search of better paying jobs, in some cases, as in Northern Rhodesia, leaving farming areas dangerouly short of manpower. European construction workers will arrive, induced by special wages out of proportion to anything earned locally. A special problem at Kariba is the relocation of 50,000 Tonga peoples whose homes will be inundated by the new lake.

Administrators in French Guinea are already evolving measures to curb inflation and mitigate as much as possible the economic and social unrest which the new era could bring. For instance, workers will be forced to save part of their earnings, looking forward to the day when basic construction is finished and their services may no longer be needed; supplementary industries are planned to absorb surplus labor; and regional investments will be made to preserve the basic agricultural economy.

Belgium created in November a National Study Institute for the Development of the Lower Congo, which will oversee the entire planning of the Inga project, from the point of view of financing, construction work, transportation and economic and social problems.



**P12/3 KARIBA HYDRO-ELECTRIC SCHEME AUG. 1957**
**Diversion Tunnel : 40 feet high by 33 feet wide, looking downstream.**

Belgium's King Baudouin has taken the view that as a result of the Inga decision, "a new harmonious and fertile collaboration between Belgium and the Congo is ahead".

It may be hazardous to generalize on the political implications of the new development schemes, but individual investors can be expected to study this aspect closely. In the Congo, Belgium's time-table for Inga, and a recent African supported time-table for "Political emancipation" both cover a thirty year period. Although Belgium's King Baudouin has taken the view that as a result of the Inga decision, "a new harmonious and fertile collaboration between Belgium and the Congo is ahead," it is clear, as the London *Times* points out, that this "bold decision" will subject the Congo to "greater outside influences, political as well as economic".

Long-term considerations will not control the decisions of investors who expect a return in the space of a few years, but taxation, governmental loan assistance, and various guarantees will be important in any case. In the French territories, local African assemblies have gone a very long way in making such guarantees. Yet, as Fortune notes, "the fact is that in Africa no less than in other parts of the world, private capital will flow only where governments, colonical or national, can guarantee the right climate and atmosphere. To the degree that this is understood, the future of Africa is unlimited. But money, like water, will not flow uphill.

# Africa's Dams: Schemes Planne

**SHIRORO GORGE, Northern Nigeria**

The green-light was given in mid-year to a major scheme for damming the Kaduna River here to provide low-cost electricity for rapidly expanding industries in Kaduna, the Northern Nigeria capital, and nearby Zaria.

**KONKOURE, French Guinea**

Plans to harness the Konkouré River and turn Guinea in French West Africa into one of the world's largest aluminum producers are nearing realization. The projected Konkouré dam will be located near the future alumina factory and aluminum smelter at Fria, and will furnish sufficient power by 1964 for an annual aluminum output approximating France's present production. American, French, British, Swiss, Canadian, Italian and German interests are participating. Meanwhile, a subsidiary of Canada's Aluminum Ltd. is planning to work extensive bauxite deposits to the north-west near Boké.

**VOLTA RIVER PROJECT, Ghana**

Prime Minister Nkrumah's Government is seeking capital to build a 600,000 kilowatt power station here and turn Ghana into a major aluminum producer, thus lessening the country's dependence on its cocoa crop.

**EDEA, French Cameroons**

Already producing electric power for the important port of Douala, the Edea project on the Sanaga River is being expanded six-fold to produce energy for the manufacture of 45,000 tons of aluminum yearly—30 per cent of present French production. French firms are building the French Union's most modern aluminum factory near the power plant.

**KOUILOU, Moyen Congo**

This project in French Equatorial Africa is an engineer's dream, capable of producing, with only one "plug" in the deep, narrow Sounda gorge, cheap electric power equal to the capacity of Kariba in its ultimate stage. Preliminary studies have been completed and an access road begun. Now, local African leaders hope the project won't be stalled because of Belgium's decision to proceed nearby with the larger Inga scheme.

**INGA, Belgian Congo**

Belgium announced its intention in November to proceed with the initial stages of the greatest hydroelectric scheme in the world, which is expected to attract major industries to the Lower Congo. An estimated $3 billion will be needed for total realization of the scheme over a 30-year period.

**CAMBAMBE, Angola**

A new private company, SONOFE, will start its first power station here on the Cuanza River. Experts say present power sources in this Portuguese territory will be inadequate within two years.

**KATANGA, Belgian Congo**

Electricity in this rich mining region comes from two major schemes already in operation of the Upper Congo, **De la Commune** and **Le Marinel**. The latter exports power to Northern Rhodesia and is big as any hydroelectric station in Europe.

# ned or Under Construction

**ASWAN, Egypt**

Egyptian officials are now looking hopefully to Japan for assistance on this controversial project. (For a detailed account of Nile development plans throughout Northeast Africa, see Africa Special Report, January 28, 1957.)

**COKA, Ethiopia**

Preliminary construction work is underway for this scheme on the Awash River 50 miles from Addis Ababa. Financed by Italian war reparations, Coka dam will create a large lake, greatly enlarge Ethiopia's electricity supply.

**OWEN FALLS, Uganda**

One of the first major dams south of the Sahara, Owen Falls near Lake Victoria harnesses the Nile at its source. Because power needs of the area are expected to exceed the dam's generating capacity after 1965, Uganda said in November it would ask the World Bank for money to build a second dam at Bujagali a short distance downstream.

**KARIBA, Federation of Rhodesia and Nyasaland**

Construction is well underway on this mammoth scheme to dam the Zambezi, create the world's largest man-made lake and provide power for a country whose economy is growing faster than any other in the world. The turbines will begin to turn in 1960.

**CHICAMBA, Mozambique**

Work has started on this Portuguese territory's largest dam, which will provide power and irrigation and back up an artifical lake as part of the Revue River scheme serving Beira and Umtali.

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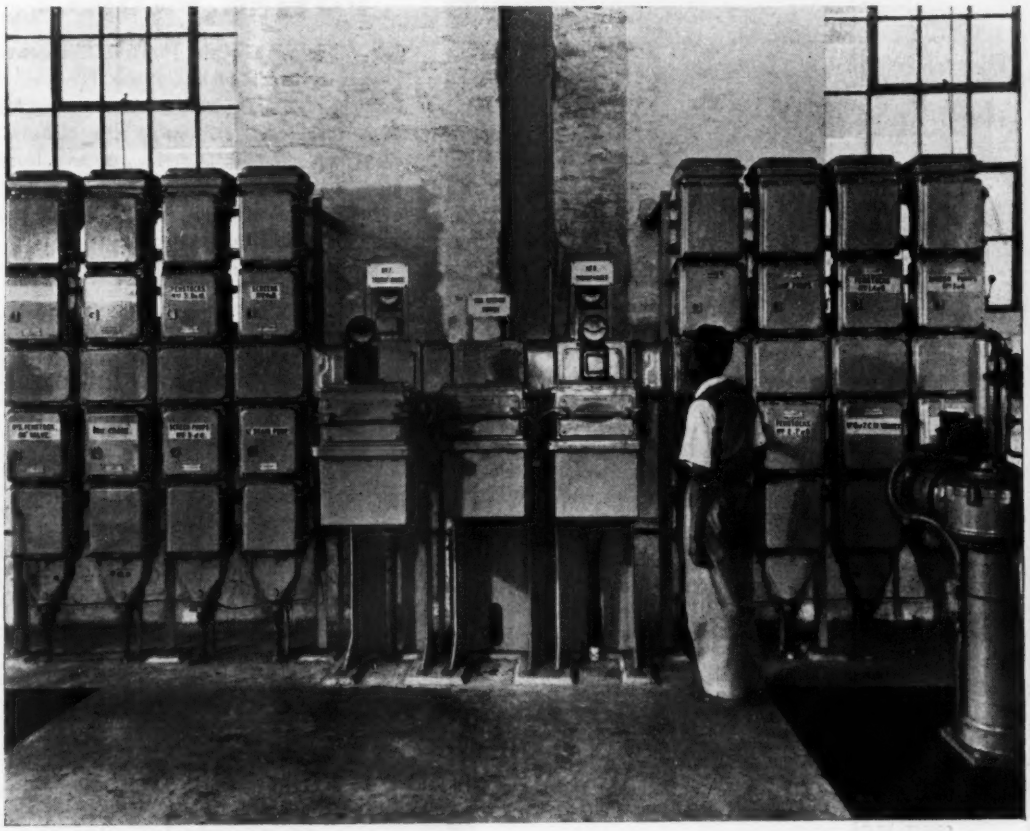

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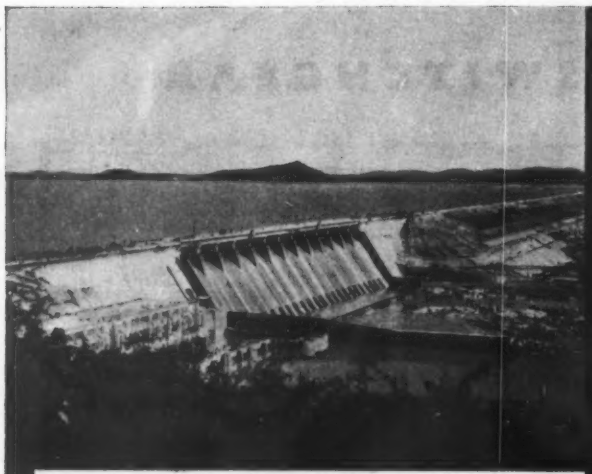

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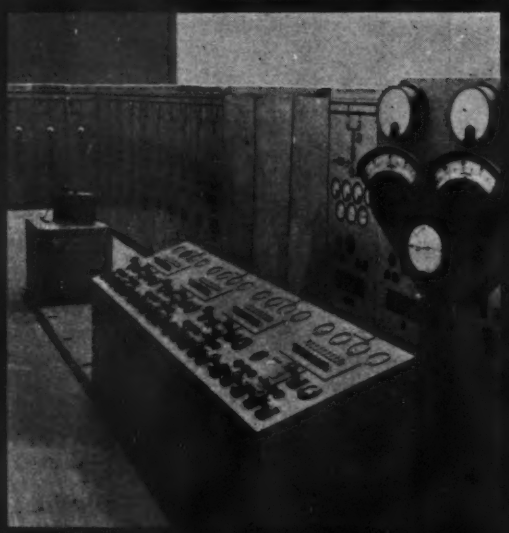

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# Progress of Major River Valley Projects in India

*This contribution is based on the Report of the Ministry of Inigation and Power, Government of India, for the year* 1957-58.

## Hirakud Dam Project

The Hirakud multi-purpose project (Stage I) has been completed and was inaugurated by the Prime Minister in January 1957. Upto the end of December, 1957 facilities for the irrigation of over 1 lakh acres were made available. The construction of the canal distribution system in the Sambalpur area (including the execution of water courses) has been accelerated in order to ensure that it is completed by 1959-60, *i. e.*, a year ahead of tne scheduled programme.

In the Main Power House, three units with a capacity of 85,500 kW have been commissioned. Installation of the fourth unit of 37,500 kW is nearing completion. The transmission grid is being extended and is at present supplying power to the Cement Factory at Rajgangpur, the Steel Works at Rourkela, the Ferro-Manganese Plant at Joda, and the Paper Mills at Brijrajnagar. In addition, power is also being supplied to Sambalpur, Sundargarh, Bargarh and other towns.

The technical staff and other workers, rendered surplus to the requirements of the project, are being released according to a phased programme. The absorption of such personnel in other river valley projects and national undertakings is being arranged. An Employment Exchange has been set up at Sambalpur for this purpose.

Surplus machinery and stores valued at about Rs. 1 crore have been sold to various State Governments and other undertakings.

Against an estimated cost of Rs. 70.78 crores for Stage I of the project, an expenditure of Rs. 54.67 crores has been incurred up to the end of November 1957.

*Mahanadi Delta Irrigation Scheme*

The Mahanadi Delta Irrigation Scheme, estimated to cost Rs. 14.92 crores, is being executed by the Government of Orissa as an adjunct to Stage I of the Hirakud Dam Project. On completion, it will provide irrigation facilities to 18-7 lakh acres in Puri and Cuttack districts.

*Hirakud Subsidiary Dam Power House Project*

*Chiplima (Stage II).*—The works on the Hirakud Subsidiary Dam Power House Project at Chiplima, estimated to cost Rs. 14.32 crores, have been progressing according to schedule. Excavation of foundation for the Chiplima Power House and of the power channel from Hirakud to Chiplima, and the construction of bridges, regulator and escapes are proceeding apace. The bridge across the power channel at Hirakud was opened to traffic on the 30th December, 1957. Over 1,611 lakh cft. of earthwork had been done in the Power Channel (including the hill channel portion) by the end of December 1957.

*Mandira Project*

The Mandira Project envisages the construction of a dam across the Sankh river to augment the water supply to the Rourkela Steel Plant. The Chief Engineer, Hirakud Dam Project, is supervising the execution of this project on behalf of the Ministry of Steel, Mines and Fuel, as a "deposit" work. It is scheduled to be completed in the record time of 11 working months.

## Damodar Valley Corporation

*Progress of Projects*

*Tilaiya.*—The Tilaiya reservoir was filled for the sixth year in succession. The Hydro-electric Station continued to function satisfactorily and supplied power to the full extent of its installed capacity of 4,000 kW.

*Konar.*—The Konar reservoir supplied water to the Bokaro Thermal Power Station and met all local, municipal and industrial demands.

*Maithon.*—The Maithon Dam which is one of the major dams of the Damodar Valley Projects, was completed during the year and was inaugurated by the Prime Minister on the 27th September, 1957. Of the three generating units of the Maithon Hydel Power House, the first was put into commission on the 30th October, 1957. The work on the remaining two units is in progress; the second set is expected to be commissioned by March 1958. All the equipment required for the power house has been received at site. The Maithon reservoir was filled for the second time this year.

*Panchet.*—Over 84 per cent of the earth dam and 69 per cent of the concrete dam was completed by the

end of November 1957. The excavation of the foundation of the power house is complete and the penstock is under erection. According to the present schedule the dam and the power house were to be completed by December 1958. Because of the damage caused by floods in September 1957, and the difficulty in getting crest gates and under-sluice gates in time, however, a further revision of the target date is under consideration.

*Barrage and Irrigation*

Over 90 per cent of the entire canal system including the navigation canal, branches and distributaries and over 75 per cent of the drainage channels were completed by the end of November 1957. The Project was scheduled to be completed by June 1958. The target date has, however, been put off till June 1959, for various reasons, namely, (1) non-availability of the Eden Canal, which forms part of the DVC Canal System for remodelling works until February 1958, (2) difficulties in procurement of cement and steel; (3) diversion of technical personnel and equipment for the construction of two additional works (diversion of Tumlla Nullah and construction of Water Supply Channel) on behalf of the Durgapur Steel Project and the Government of West Bengal; (4) non-availability of a sufficient number of contractors willing to accept work at reasonable rates. During the year, about 1,43,000 acres of land were reported to have been irrigated in West Bengal.

*Transmission and Distribution System.*—The work on the DVC transmision and distribution systems is proceeding according to schedule. A table showing the progress is given below:—

Out of 498 route mile of transmission lines and 29 sub-stations and receiving stations envisaged in the Firts Stage of the transmission system, over 489 route mile and 25 sub-stations and receiving stations have been completed. Out of a total of 338 route miles of the extension of the transmission lines to Calcutta, Gaya, Patna and Dalmianagar, over 275 route miles have already been completed. About 80 per cent of the work on five new 132 kV sub-stations and extension to three existing sub-stations, has been completed. About 40 per cent of the work on the extension of the transmission system, for supply of power to the Eastern Railway has been completed. Power supply to the railways has been given from the Howrah Grid Sub-station and temporarily through a mobile sub-station at Belmuri. Permanent arrangements for the supply of power to the railway from Belmuri and Burdwan are in progress, and are expected to be completed by the middle of the next year. Survey work in regard to the construction of 110 miles of 132 kV lines from Maithon to Sultanganj, undertaken on behalf of the Government of Bihar is in progress. Miscellaneous works such as the conversion of single circuit lines into double circuit lines, from Konar to Gaya, Patna and Dalmianagar, and extension to the existing sub-stations and receiving stations etc., are progressing satisfactorily.

*New Thermal Power Installations.*—All the existing 3 units of 50 mW capacity each of Bokaro Thermal Power Station had to be operated without any stand-by. To meet the increasing demand for power, steps have been taken to augment the capacity of the DVC power system by installation of a new thermal power station of 150,000 kW at Durgapur and a fourth unit

| *Sl. No.* | *Item of work* | *Scope of work as planned* | *Total progress upto end of Nov. 1957* | *Anticipated progress upto 31-3-58* |
|---|---|---|---|---|
| 1. | 132 kV transmission lines including 110 miles of Maithon-Sultanganj (Bihar Govt. work) and 90 miles of 132 kV tie line between Panchet Hill and Jamshedpur. | 913 miles | 641 miles | 670 miles |
| 2. | 33 kV D/C Lines | 91 miles | 91 miles | 91 miles |
| 3. | 132 kV Grid Sub-station | 16 Nos. | Out of 16 Sub-stations 8 Nos. have been 100% completed and as regards the balance of 8 Nos. through they have been commissioned and power is being supplied therefrom, the percentage of construction progress is as below:— | |
| | | | per cent | per cent |
| | | | Burdwan 72 | 75 |
| | | | Kharagpur 90 | 95 |
| | | | Barhi 61 | 70 |
| | | | Howrah 80 | 90 |
| | | | Gaya 89 | 95 |
| | | | Dalmianagar 68 | 70 |
| | | | Patna 51 | 60 |
| | | | Belmuri 19 | 30 |
| 4. | 33 kV Receiving Station | 13 Nos, | 12 completed | 13 Nos. |

with a capacity of 75,000 kW at the Bokaro Thermal Power Station. Tne works on these schemes are now in progres. . About 10 per cent of the entire work was completed by the end of November. 1957.

*Power Development.*—(*i*) The load on the DVC Power System has grown very rapidly and the aggregate demand for power rose from 22,280 kW in 1953 to 160,200 kW by the end ofNovember 1957. The Bokaro Thermal Power Station supplied 157,500 kW of power as against its firm capacity of 100,000 kW; under normal operating conditions, one unit is to be kept as a stand-by. The Tilaiya Hydro-electric Power Station supplied power to the full extent of its installed capacity of 4,000 kW. One set of 20,000 kW, out of the 3 sets at Maithon Hydro-Electric Power Station, was commissioned in October1957. In view of the acute power supply position in the DVC area, a small amount of power is being purchased from the Sindri Fertilizer Factory. This arrangement will be continued till the second and third units of the Maithon Hydel Station are commissioned.

(*ii*) The following new supplies were commenced during the year:—

| | |
|---|---|
| (1) Calcutta Electric Supply Corporation—Howrah Sub-station | April 1957. |
| (2) Eastern Railway—Howrah Sub-Station, for track electrification of Howrah-Bandel Section .. | October 1957 |
| (3) Government of Bihar—Barun | October 1957 |

(*iii*) The Government of Bihar is now taking power from the DVC at 9 points. Supply of power at another point at Patna will commence shortly.

(*iv*) New contracts were executed during the year with the following parties for supply of additional power at places showed against them:—

| | |
|---|---|
| (1) Government of Bihar at Ramgarh | 2500 kVA |
| (2) ,, ,, Digwadih | 1250 kVA |
| (3) ,, ,, Badjna | 1600 kVA |
| (4) ,, ,, Ganeshput | 2700 kVA |
| (5) *Dishergarh Power Supply Co. Ltd.* | |
| Dishergarh .. .. | 2000 kVA |
| Kumardhubi .. | 2000 kVA |
| (6) Associated Power Co. Ltd. at Luchipar .. | 2700 kVA |
| (7) Indian Iron & Steel Co. Ltd. at Kulti .. .. | 2000 kVA |

(*v*) The Calcutta Electric Supply Corporation Ltd., has notified that their demand in 1960 on the DVC Power System will be 95,000 kVA. The present sanctioned capacity of 563,000 kVA (479,000 kW), which will provide a firm capacity of 414,000 kVA (352,000 kW), will be completely utilised as soon as new installations are commissioned. The area commanded by the DVC system is being surveyed to assess future demand for power.

The quantity of power sold and the revenue earned from April 1957 to November 1957, are shown below:—

| | |
|---|---|
| Energy Sold .. .. | 495,787,767 kWh |
| Gross Revenue .. .. | Rs. 2,15,54,480 |

*Utilisation of Water for Irrigation*

(*i*) *West Bengal.*—With the completion of the Durgapur Barrage in April 1955, and the progress made in the construction of the Irrigation System, the Corporation supplied water during 1957 to an area of about 143,000 acres under Kharif crops in West Bengal.

(*ii*) *Bihar.*—Two schemes for the utilization of the water of the Tilaiya Reservoir for irrigation in Bihar have been prepared by the D.V.C. The first, *viz.*, the Tilaiya High Level Irrigation Scheme is estimated to cost Rs. 35 lakhs and will provide irrigation to 10,000 acres of Kharif land and 5,500 acres of Rabi land. The second scheme estimated to cost Rs. 1,14,500 contemplates the irrigation of 500 acres by opening an outlet from the reservoir. Both the scheme are under examination.

*Other Works*

*Soil Conservation.*—An account of the soil and water conservation work carried out during the year under report, is given below:—

*Soil Survey.*—96.33 sq miles were surveyed for soil conservation, bringing the total area surveyed to 512 sq. miles. 20 sq. miles were also geologically surveyed, the total area so far surveyed being 320 sq. miles.

*Research.*—Studies to determine the effect of various crop management practices with a view to finding out a suitable cropping system for the uplands of the region were continued. The effect of various terraces on upland crops was also studied. Studies on the economics of terrace construction by manual labour and bullocks were started. Experiments were continued for finding out the nutrient requirements of various crops, renovation of grazing lands, and methods of planting promising grasses. Studies were also started on the efficiency of the village and farm bullocks for various field operations.

*Soils Laboratory.*—The Soils Research Laboratory at Hazaribagh continued the analytical work on samples of soil, rocks, water, plants, fertilizers, etc.

*Demonstration Scheme.*—A pilot Soil Conservation and Demonstration Scheme was carried out in the villages around the Gonda Reservoir (Hazaribagh) to demonstrate to the villagers the value of various soil conservation practices. The uplands were terraced and consolidated and cropping on contour was done in about 57.14 acres.

*Use of Land emerging from Bigger Reservoirs*—With a view to utilising the land emerging periodically from the 4 major reservoirs of the Damodar Valley, the experimental station and the two demonstration centres on the periphery of the Tilaiya reservoir and the demonstration centre at Konar were engaged in popularising the cultivation of deep water and semi-deep water paddy during the Kharif season and wheat, barley, potato and other rabi crops during the rabi season. The villagers have started appreciating the work done at these farms and deep water paddy cultivation has been taken up in 7 villages adjoining the Tilaiya reservoir and 4 villages adjoining the Konar reservoir. A total area of 2,500 acres was leased out for cultivation at the two farms and more area is expected to be brought under cultivation during the coming season.

*Soil Conservation Scheme, Sewani*—Intensive soil conservation measures continued in an area of 35.44 sq. miles in the Upper Sewani catchment. These include upland treatment, pasture development, afforestation improvement of existing forests and gully stabilisation. Upto November 1957, work has been done in 823 acres of upland area. Construction of small check dams and gully plugging for stabilising about 300 acres of eroded land have already been undertaken under this scheme.

*Extension*— To help and guide the culivators in adopting improved agricultural techniques based on the principles of soil conservation, demonstration on conservation farming were conducted in about 922 acres in 20 villages in collaboration with cultivators. In addition, small preparatory agricultural demonstrations were conducted in about 60 acres in 112 villages. Work had also been started to find out the economics of conservation farming.

*Agricultural Experiment Station, Panagarh.*—This station continued to conduct experiments on various problems connected with irrigation farming. The yield data collected after experiments on various types of Aus and Aman paddy were analysed and compilation of statistics was in progress.

*Forestry*—The Forestry Section of the Soil Conservation Department has so far afforested nearly 3,000 acres. In addition, another 450 acres have been fenced as a part of the annual afforestation programme of 1,000 acres. A three acre permanent nursery and several temporary nurseries are maintained for raising seedlings for transplanting during the monsoon.

*Fishery*—Exploitation of the fisheries of the Tilaiya and Konar reservoirs was taken up. Preparations for launching more fishing units for exploitation on a large scale were in progress. Survey of other fishery resources with special reference to future storage reservoirs of the valley was conducted.

*Training Scheme*—Under the training scheme of the Central Soil Conservation Board, training in all phases of soil conservation continued to be imparted to candidates deputed from the various States. The sixth batch of 25 candidates is now receiving training.

*Rehabilitation and Reclamation*

The majority of displaced persons of the Maithon reservoir area have shifted from the submergence area and constructed houses on different sites. Payment of compensation to displaced persons of Dhanbad and Jamtara Sub-divisions in Bihar and Asansol Sub-division in West Bengal, has been completed except in cases where replacement of land is involved according to the option given by the affected people. Out of 4,602 families involved in submergence, only 650 asked for replacement of their lands. The rest of the families were paid compensation in cash. None of the displaced families wanted replacement of their houses. They were, therefore, paid compensations for their houses in cash. Out of an area of 1,183 acres reclaimed in Dhanbad Sub-division, only about 129 acres have so far been accepted. The work of rehabiliation in Jamtara Subdivision is now being done by the Government of Bihar.

In Panchet area, out of a total of 7,365 families to be affected by the reservoir, only 49 families opted for lands reclaimed by the Corporation and 587 families for culturable waste lands to be reclaimed by themselves. The remaining 6,729 families will have to be paid cash compensation. Payment of compensation in more than half of the affected villages, has been completed and it is expected that before actual submergence starts, payments in respect of the remaining villages will also be completed.

*Other Development Activities*

The Lock Manufacturing Factory at Tilaiya and the Hand Tool Finishing Workshop at Maithon were transferred to the Government of Bihar, in September 1957. The Cold Storage Plant at Burdwan was put into commission in March 1957.

*Labour and Welfare*

Efforts continued to be made to find alternative employment for the staff rendered surplus due to the completion of work on certain projects. Out of approximately 3,000 employees retrenched upto the middle of November 1957, all but 250 have found alternative employment.

## Bhakra-Nangal Project

The main component parts of the Bhakra-Nangal Project are:—

(*i*) (*a*) Bhakra Dam, 740 ft. high;
(*b*) Two power houses at the foot of the dam;
(*c*) Two 50 ft. diameter concrete-lined diversion tunnels each half a mile long;

(*ii*) Nangal Dam, 90 ft. high;

(*iii*) Nangal Hydel-Channel, 40 miles long;

(*iv*) Two power houses on the Hydel Channel at Ganguwal and Kotla;

(*v*) Bhakra Irrigation Canals and Distribution System;

(*vi*) Remodelling of the Rupar Headworks and the Sirhind Canal;

(*vii*) Bist Doab Canal; and

(*viii*) Transmission system.

All works, except the Bhakra Dam and its two power houses and the transmissin system, have been completed.

The concreting work on the Bhakra Dam, which commenced on the 17th November, 1955, is making steady progress. A total quantity of 23,78,000 cu. yds. of concrete was poured in the Dam upto the end of December 1957. The whole operation is highly mechanished. The aggregate obtained from the quarries at Fatehwal and Neilla is carried to the Batching and Mixing Plant through belt conveyers, after it has been processed, classified and cooled on the way by passing through the screening and cooling plants. Mixed concrete from the Batching and Mixing Plant is carried in concrete buckets over concrete cars and placed in the block by cranes mounted on trestles. The work on the Dam proceeded round the clock in three shifts. The Dam is scheduled to be completed in 1959-60.

A plant for the manufacture of pozzolan, has been put into operation. The use of pozzolan will not only reduce the cost but also conserve the available supplies of cement.

Work on the two power houses at the foot of the dam is proceeding apace. The erection of pen-stocks in the left bank power house, which will have 5 generating units of 90,000 kW each, is in progress. The civil works of this power house are expected to be completed by the end of September 1958. The right bank power house will eventually have 5 generating units of 90,000 kW each; these will be installed as and when necessity arises. Orders for the units on the left bank power house have been placed, and the first unit is expected to go into operation late in 1959. The remaining 4 units will be commissioned at intervals of 3 months each.

The power house at Ganguwal, with two units of 24,000 kW each, was commissioned in 1955, and the power house at Kotla with an equal capacity in July 1956. It is proposed to instal an additional unit of 29,000 kW in each of these power houses. With the installation of these units, and 5 generating units in the left bank power house, there will be an installed capacity of 6,04,000 kW and firm capacity of 3,32,000 kW.

The work on the Punjab portion of the main transmission line is nearing completion. In Rajasthan, the work is being speeded up.

Adequate amenities and welfare facilities continue to be provided to labour by way of rent-free accommodation, medical facilities, recreational centres, schools, etc. A weekly holiday is being allowed to all workers.

The Bhakra reservoir will submerge about 256 villages in Bilaspur District of Himachal Pradesh and 110 villages in the Kangra District in the Punjab. Some of the oustees will be settled on the land available above the reservoir. It is proposed to rehabilitate the others in the Hissar District. The amount of compensation paid till November 1957 for land and property acquired for the reservoir, was Rs. 85 lakhs. The existing Bilaspur town will be submerged by the Bhakra reservoir. A new Township is being constructed about 2 miles away from the existing town at a higher elevation.

The Bhakra system is expected to irrigate about 20 lakh acres in the Punjab and Rajasthan during 1957-58 as against 15-47 lakh acres during 1956-57.

The revised estimate of the Bhakra-Nangal Project is Rs. 170.02 crores. An expenditure of Rs. 137.16 crores, including the commitments made but excluding interest charges, was incurred upto the end of October 1957.

### Tungabhadra Project

The Tungabhadra project, which was started in 1945 as a joint enterprise of the States of Madras and Hyderabad has, due to the reorganisation of States, become a joint venture of the States of Andhra Pradesh and Mysore. The project consists of a masonry dam across the Tungabhadra, a 127 mile canal with a power house on the left side, and a 225 mile canal, called the Low Level Canal, with two power houses on the right side. An area of 6,71,600 acres in Mysore and 1,56,900 acres in Andhra will receive irrigation benefits. Under the final scheme, 1,08,000 kW of power will be generated.

The main Dam has been completed except for some minor works which are likely to be completed by March 1958. One generating unit of 9,000 kW was commissioned in the right-bank Dam Power House in January 1957, a second unit with the same installed capacity in May 1957. The Hampi Power House, with two units of 9,000 kW each, was expected to be commissioned shortly. The work on the left bank Dam Power House is proceeding according to schedule.

The Low Level Canal, including the power channel, and its major distributaries, has been completed The distribution system and field channels in Andhra Pradesh have also been completed. More than 80 per cent of the distribution system and more than half of the field channels in Mysore have been completed. On the left side, 52 miles of the main canal have been completed, and water has been let out up to this reach. Work between miles 52 and 65 has been completed, except for approaches to masonry works which are in various stages of progress. Between miles 66 and 103, earth-work and lining are nearing completion. The alignment of the remaining length upto mile 127 has been finalised.

A total area of about 80,000 acres was brought under irrigation on both sides of the river by October 1957. As the region had heavy rainfall this year, full use of the available water could not be made.

### Kosi Project

The main features of the Kosi scheme are:—

*Unit I.—Hanumannagar Barrage and Headworks*—A barrage will be constructed across the Kosi river about 3 miles upstream of Hanumannagar in Nepal. It will have earth flanks and the following masonry structures:—

(*i*) a main spillway; and
(*ii*) a head regulator for a future canal on the western side and a head regulator for the Eastern Kosi Canal.

*Unit II.*—Flood embankments (about 150 miles in length) and protective measures.

*Unit III.—Eastern Kosi Canal System*—The Eastern Kosi Canal which will take off from the Hanumannagar Barrage will have a gross commanded area of 18.23 lakh acres and an annual irrigation of 13-97 lakh acres. The main canal will have four branches, namely, Supaul branch, Partapganj branch, Purnea branch, and Arraria branch.

The progress of works on the project is given below:—

(*a*) *Embankments*

Work was started in January, 1955. In spite of initial difficulties and the limited duration of the working seasons, the progress on the construction of the embankments has been striking. About 135 miles of embankments, involving 60 crore cft. of earthwork, were completed by the end of the last working season (1956-57); 40 per cent of the work was done through public co-operation agencies.

(*b*) *Preliminary Works for the Construction of the Barrage*

A 26 mile-long access road has been constructed from Bathnaha to Bhimnagar *via* Birpur. 60 miles of track have been laid for the narrow gauge railway line from Bathnaha to Bhimnagar and to Chatra and Dharanbazar. Temporary bridges in the Bhimnagar-Chatra Dharan section have been put up. Trial runs with wagons on locomotives have been arranged between Bathnana and Bhimnagar and Chakarghatti. Arrangements for locomotives and other equipment are in hand. Material has been acquired for 14 miles of the 17-mile tramway track from Gangajali to Bharda. Colonies at Nirmali, Supaul, Bhaptiahi, Pratapganj, Kataiya and Dharan have been completed; the others at Birpur, Bathnaha and Bhimnagar are nearing completion. Office buildings and other miscellaneous structures are also nearing completion.

(*c*) *Barrage*

2.89 lakh c. ft. of rip-rap material, 1.17 lakh c. ft. of filter material and 1838 tons of sheet piles have been collected. A small screening plant has been installed and rope-way fittings are being fabricated. Small workshops have been set up.

(*d*) *Canals*

Surveys and investigations in respect of the Main Canal, the Supaul branch and the Pratapganj branch have been completed. Excavation of some reaches of the Main Canal involving 330 lakh c. ft. of earth work, has been done. Investigations of the Chatra canal is in progress.

The programme for the current working season is:—

(*a*) *Embankments*

Completion of the residual work on the embankments, except western afflux bund.

(*b*) *Preliminary Works for the Construction of the Barrage*

(*i*) Completion of 21 per cent of the work of pre-mix carpetting on the access road and the construction of wing walls of bridges and culverts, (*ii*) the 16 miles of railway line including construction of bridges and culverts, with the exception of 4 major bridges, and (*iii*) the colonies.

(*c*) *Barrage*

(*i*) Commencement of regular work on the barrage, (*ii*) erection of a permanent screening plant and serial rope-way, and (*iii*) completion of the construction of eastern earth dam.

(*d*) *Canals*

832 lakh c. ft. of excavation work in respect of the Eastern Kosi Canal system.

The expenditure incurred on the project upto the end of December 1957, was Rs. 9.43 crores.

## Koyna Project

The Koyna Hydro-electric Project (Stage I) comprises the construction of a concrete-*cum*-masonry dam across the Koyna river, an underground power house capable of generating 2,40,000 kW of power at 60 per cent load factor and a double circuit 220 kW transmission line to Trombay to be tied into the Tata's Power System at that place.

Construction was commenced on 16th January, 1954. Preliminary works have been completed at the dam-site at Koynanagar and at the power house site at Pophali. The progress of work on each main component of the Project is briefly given below:—

(*i*) *Dams*

The upstream and downstream coffer-dams and the diversion channel on the right bank, have been completed. Most of the over-burden in foundations has been removed. Excavation in rock on both flanks is also nearly complete except in the river bed monoliths, where the foundations are to be taken about 50 ft. into exposed weak rock. Work on these deep foundations is in progress. Consolidation grouting of rock in the foundations where excavation is complete, is in progress. Installation of the concreting plant is nearing completion.

(*ii*) *Intake to Emergency Valve House*

Excavation of the intake channel and the Head Race Tunnel is in hand. Open excavation of the surge system is nearly over and underground excavation has been started.

(*iii*) *Pressure Shafts, Power and House Appurtenances*

Excavation of the approach tunnel (2,850 feet) and ventilation tunnel (1,209 feet) has been completed to enable excavation of the 3 power house caverns to be started. Excavation of the arched roofs of the three caverns is in hand. Work on the switch-yaar cable tunnel and intermediate adit to pressure shafts has been started.

(*iv*) *Tail Race Tunnel*

The Tail Race Tunnel which is to be 7,500 feet long is being constructed departmentally and has progressed up to 3,677 feet by 1st December, 1957.

(*v*) *Electric Machinery*

Orders have been placed for the turbines, generators, transformers, workshop cranes, outdoor switch-gear, etc. The work of construction of transmission towers has been given out on contract. The designs of towers have been finalised and foundation-stub-steel fabrication is going on.

(*vi*) *Research and Designs*

A research laboratory has been set up to meet the needs of quality control and design of concrete mix for the Dam.

Negotiations for a dollar loan from the International Bank for Reconstruction and Development are in progress.

The actual expenditure incurred on the project up to the end of November 1957 was Rs 7.04 crores.

## Rihand Dam Project

The Rihand Dam Project, estimated to cost about Rs. 45 crores, envisages the construction of a concrete gravity dam across the Rihand river near the village of Pipri in Uttar Pradesh. The dam will be about 3,000 feet long and about 270 feet high above the river bed. The power house at the base of the dam is designed

to house five generating sets, each of 50,000 kW capacity. 132 kV and 66 kV transmission lines, to Allahabad, Mirzapur, Sultanpur, Varanasi, Mau, Gorakhpur, etc., will be constructed to carry power to eastern parts of Uttar Pradesh. Power will be supplied to operate tubewells capable of irrigating about 16 lakh acres in Uttar Pradesh and about 5 lakh acres in Bihar. Large-scale industrial development including the production of aluminium, paper, textiles fertilizers and plastics, is expected to take place in the neighbourhood of the dam-site as raw materials are available locally. Some power will also be made available to Madhya Pradesh for domestic use and the development of cottage industries.

The preliminary work on the construction of the project was commenced in 1948, but had to be slowed down in 1949, owing to the urgent need, at that time, of transferring all available personnel material and funds to short-term food production schemes. Work was resumed in October 1951.

The 3,300 feet long pre stressed concrete road bridge over the river Sone has been completed thus providing an all weather A class access road to the dam-site, form the rail head at Robertsganj, and the Cement Factory at Churk. The access road has also been widened and improved and made fit for heavy traffic. The erection of a 3,000 kW diesel station at the damsite and a 6,000 kW steam station at Chopan has been completed and the power houses put into operation for supplying power for the plant and machinery employed in construction.

The contract for the construction of the dam was awarded to Messrs Hindustan Construction Co. Ltd., in March 1955. Work on the excavation of the foundations of the dam commenced in April 1955, and is proceeding according to schedule. Partial concreting operations were started in April 1957, and concreting reached full swing in December.

The expenditure on the project up to the end of November 1957 was Rs. 9.40 crores.

**Chambal Project**

The Chambal Project is a multi-purpose scheme and is being executed jointly by the Madhya Pradesh and Rajastnan States. It envisages the construction of three dams with a power house at each, and a barrage across the river Chambal near Kotah with canals on both sides for irrigation. The project will ultimately produce 2.10 lakh kW of power at 60 per cent load factor and irrigate 14 lakh acres.

The execution of the project has been planned in three stages. The first stage, estimated to cost Rs. 48.08 crores, has been sanctioned; a revised estimate amounting to about Rs. 63 crores is under examination. Stage I of the project consists of:—

(*i*) Gandhi Sagar Dam at the border of Madhya Pradesh and Rajasthan States. The dam will be 204 feet high and 1,685 feet long at the top, and will create a storage of 6.85 million acre feet.

(*ii*) A Power House at the Gandhi Sagar Dam to accommodate five units of 23,000 kW each—three units are being installed in the fist stage.

(*iii*) 911 miles of Transmission Lines in both the States.

(*iv*) Kotah Barrage.

(*v*) Canals on both sides of the river—162 miles in Rajasthan and 398 miles in Madhya Pradesh.

The first stage is scheduled to be completed in 1962. It will generate 75,000 kW of power and irrigate 11 lakh acres of land. Some irrigation supplies and power are expected to be made available in 1959.

The progress on the principal works comprising the first stage of the scheme, till the end of December 1957, is given below:—

(*a*) *Gandhi Sagar Dam*

In a major portion of its length, the dam has risen 100 feet above the bed level. 50 per cent of the total of 256 lakh cubic feet of stone masonry and concreting in the body of the dam has been done. The dam is expected to be completed by June 1959.

(*b*) *Gandhi Sagar Power House*

77 per cent of the total of 6.5 lakh cubic feet of stone masonry and concreting has been completed. Orders have been placed for generating plant which is expected to be received by the middle of 1958. The penstock pipes have arrived at the site and welding work is in progress. The power house is expected to be ready with the completion of the dam.

(*c*) *Transmission Lines*

In Madhya Pradesh, the work on transmission lines for distribution of power to the various Grid Sub-stations is being taken up. The work relating to foundations for terminal towers is in progress, and equipment for erection of transmission lines has started arriving. Most of the buildings required for the operation staff of the Grid Sub-station at Ujjain and Indore have been completed, and are under construction at other places. The transmission lines will be completed by the time power is made available from the Gandhi Sagar Power House.

In Rajasthan, a detailed survey for the transmission lines, is in hand. Tenders for material and equipment required for the transmission lines are under scrutiny.

(*d*) *Kotah Barrage*

88.5 per cent of the total of 60 lakh cubic feet of rock-cutting and 80 per cent of the total of 27 lakh cubic feet of masonry and concreting have been completed. The gates for the barrage are being manufactured at the Tungabhadra Workshop.

(*e*) *Canals in Madhya Pradesh and Rajasthan*

In Madhya Pradesh, 20 per cent of the total earthwork and 39 per cent of rock-cutting have been completed. Eight per cent of the masonry and concreting for cross-drainage works has been done.

In Rajasthan, the work is proceeding according to schedule Construction of all the major cross-drainage works has been taken in hand.

Some major works, both in Rajasthan and Madhya Pradesh, have been entrusted to the National Projects Construction Corporation.

Consistent with economy and achievement of adequate progress, local labour and labour co-operatives have, with the help of public workers and the Bharat Sewak Samaj, been encouraged to undertake work on the Project whenever possible.

The expenditure incurred on the project up to the end of December 1957 was Rs. 13.35 crores.

### Nagarjunasagar Project

The Nagarjunasagar Project, which is a scheme of the Andhra Pradesh Government, comprises the construction of a masonry dam on the Krishna river near Nandikonda village and two canals, one on each side of the river. The Right Bank Canal, 135 miles long, will irrigate 9.7 lakh acres. The Left Bank Canal, 108 miles long, will irrigate an area of 7.9 lakh acres. An additional area of 3 lakh acres in the Krishna delta will also be brought under irrigation. The total area to be irrigated under the project is, therefore expected to be 20.6 lakh acres yielding about 8 lakh tons of foodgrains.

The dam will be built of stone masonry and provided with eight penstocks, each 14 feet in diameter, for eventual generation of power in the final stage of the project. The height of the Dam would be 290 feet above foundation level in the Spillway Section and 330 feet in the non-spillway Section. The project is expected to be completed by the year 1963-64.

The work on the project was inaugurated on the 10th December, 1955. The preliminary stage of the project has been completed and execution of major items of work has commenced. The progress of work done during the year under report is summarised below:—

(*a*) *Dam*

A coffer dam, 3,000 feet long and 40 feet high involv- 1.8 million cubic feet of masonry has been completed. The total quantity of masonry and concrete involved in the construction of the main dam is over 185 million cubic feet of which 3.24 million cubic feet have been done up to the end of December 1957

(*b*) *Right Bank Canal*

Preliminary and detailed investigation of the canal up to 135 miles has been completed. Block levelling of the entire ayacut of 36.65 lakh acres has been almost completed. Excavation of the canal is in progress in 10 reaches between miles 6 and 17.

(*c*) *Left Bank Canal*

Preliminary investigation for a length of 91 miles and detailed investigation for a length of 66 miles have been completed. Block levelling of 2,17,079 acres has so far been done. Excavation of the main canal is in progress in 7 reaches between miles 6 and 16. The Bharat Sewak Samaj has been entrusted with the excavation work for two miles costing Rs. 11.55 lakhs of which work costing Rs. 4 lakhs has been completed.

1,147 residential buildings have been constructed, and 1.300 huts for departmental labour have been provided. The bridge across the Krishna river was opened to traffic on 28th November, 1957. Eight miles of railway line out of a total length of 11.6 miles, from Macherla to the dam-site, have been laid.

The total cost of the project is estimated to be Rs. 86·33 crores. Budget provision for the year 1957-58 amounts Rs. 6.5 crores. The total expenditure incurred up to the end of December 1957 was Rs. 10·73 crores.

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## FURTHER SUBMARINE POWER CABLE COMMISSIONED IN CANADA

A second ciruit in the 138,000-volt submarine power cable link between Vancouver Island and the mainland of British Columbia has been recently put in commission. The cable was manufactured for the British Columbia Electric Company by British Insulated Callender's (Submarine Cables) Limited at their Trafford Park Works, Manchester. British Insulated Callender's Construction Company Limited, who were responsible for the laying and testing, chartered H. M. T. S. Monarch to transport the cable from Manchester to Vancouver and to lay the four continuous lengths between the mainland and Vancouver Island.

The existing submarine power cables, which were also manufactured and installed by the BICC Group have been in successful operation since September 1956. These, with the two continuous lengths of 16 miles and two of about three miles, required to complete the second circuit, plus a spare cable, bring the installed length of submarine cable for this remarkable power link to a total of over 133 miles. The combined current-carrying capacity of the two circuits, which bring Bridge River hydro-eectric power to Vancouver Island, is now 250,000 kilowatts, a capacity greatly in excess of that of any similar undertaking in the World.

The 138,000-volt cable is of the single-core gas-pressure type. The 0.35 square inch conductor consists of a spiral steel duct over which are applied two layers of copper wires and a conducting screen of three impregnated metallized paper tapes. The dielectric, which itself is screened with copper tape, consists of pre-impregnated paper tapes. The lead alloy sheath is reinforced by tin-coated bronze tapes over which is applied vulcanized rubber. Then follows a jute yarn bedding and single layer of galvanized steel wire armouring. These wire are protected by two bituminized layers of jute yarn.

The overall diameter is nearly four inches and the weight of the entire 133-miles of cable is about 5,400 tons.

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# Gauging Work: Its Significance and Progress with special reference to the Pre-Reorganisation Bombay State

By R. L. PHANSALKAR

## Part I

1.1. Scope and Significance of Gauging Work: Gauging includes work of (i) Observation and recording of precipitation data, and (ii) measuring with necessary devices and the recording of the Discharge of rivers and streams. With the advance of Engineering and allied sciences it is not enough for the civil engineer concerned with water supply, irrigation, power, drainage and flood control to be able to determine the form of structure best suited for these purposes: he must be in a position to determine the quantities of water that must be handled. The civil engineer can undertake hydraulic design of a structure only after full knowledge of the hydrologic design, just as structural engineer proceeds to determine the size of members, only after calculating the load that may eventually come upon the structure.

1.2 Availability of water is often the ruling factor in the location of important structures and the limiting factor in the growth of cities. Knowledge of hydrology with the help of meteorology and weather science enables us to estimate the quantity of precipitation, rainfall fluctuations, actual surface runoff and likely recharge to ground water. Measurements of rain-fall and of the flow of streams and of ground water and analysis of the observed data for a period of years, enable the hydrologist to make quantitative predictions of flood, normal flow and drought and the water intake into the soil-mantle and into under-ground reservoirs and calculate the evaporation and transpiration losses. He also studies the methods of developing water resources and predicts the effects of the proposed schemes and improvements on the regimen of streams and ground-water reservoirs.

2.1 Purpose of this paper: It is well-known that the earth's total available supply of moisture is constantly in circulation barring deep ground-water supply. The process of circulation seems to be composed of the following steps:—

(*i*) Transfer of moisture from the atmosphere to the earth by condensation and precipitation.

(*ii*) Distribution of a portion of the precipitated water by surface and underground channels to the Oceans and inland bodies of water.

(*iii*) Return of moisture to the atmosphere by evaporation from oceans, lakes, and swamps by evaporation from the surface of the soil and the surface of the plants that intercepted precipitation: and by transpiration from plants and vegetation in their growing process.

The entire process of circulation and redistribution of water by the atmosphere and the earth is known as the Hydrologic cycle. This cycle is constantly achieving a balance between the waters of the earth and the moisture in the atmosphere. For continental areas the balance is represented by the equation:

$$P = R + E,$$

where P is the precipitation, R the runoff and E the Evaporation and other losses, energy to sustain the hydrologic cycle being derived from the Sun.

2.2. Hence, to assess the water-potential of any composite or independent tract of land, means of observation and study of the Rainfall, Runoff and Evaporation and other Losses must be provided, established, and daily record maintained, analysed, reviewed and published for the guidance and use of Engineers, Agronomists, Geologists and Meteorologists, as well.

2.3. The basic hydrologic relation $P=R+E$, which both gives the law and explanation of the Hydrologic Cycle and phenomenon, gives at once the basis and pattern for the organisation of the study and collection of data and preparation of record, pertaining to the entire hydrologic phenomenon, over an area.

2.4. For the knowldge of Precipitation (P), we must have a number of Rain-Guages, Self-recording and ordinary; for measuring Runoff (R), discharge observation sites and adequate means, instruments and implements including suitable gauge runs and gauges (also spelt as 'Gages'), velocity rods, currentmeters and gauge posts, etc., and evaporimeters, thermometers (Dry and Wet Bulb), and maximum and minimum temperature recording thermometers) and Barometers, also, are required to be provided and gauging stations established over a number of appropriate

points, and places in each River Valley and studies organised for each set of valleys or the valley-area bounded by state boundary, rather than for only a group of districts or individual state-units.

2.5 As is well-known, the rainfall at any place varies from year to year and so also does the annual discharge of streams. Hence, in order to be able to estimate with any reasonable degree of accuracy, the average rainfall of a place or the average annual discharge of a stream, at a particular site it is necessary to have data collected and observations made for a large number of years continuously; and, that is why, proper rain-gauges, climatological stations, and discharge observations or gauging sites, have to be established and maintained in efficient functioning order and worked properly.

2.6. The number required, staff needed, and cost involved, will depend on the importance, water-potential and prospective nature of development of each valley, and an attempt will be made in this paper to outline a few details pertaining to these and their importance, indicate the nature of such recording including tabulation, graphical work, duties of operator-staff after outlining the nature and characteristics of the rainfall and the catchments in the Pre-Reorganisation Bombay-State.

2.7. An attempt will also be made to outline the method of working and the stage of progress achieved here, the work still required to be done and the significance of getting a full correct and complete picture of the Water-Potential of the Bombay State with its inherent prosperity, and also the care and responsibility involved in correctly estimating, handling and developing the water-resources of the State and thereby enhancing the State's prosperity.

3.1 Early notions and Work in the field of Hydrology. It is very interesting and instructive to learn how the Pioneers in Europe, in the field of hydrology proceeded to establish the relationship between Precipitation and Runoff.

3.2 Pierre Perrault (1608-1680), a Frenchman, made measurements of the rainfall in a part of the Seine River basin during three (3) years and estimated the area of the drainage basin above the point where he had measured its flood-runoff and thus computed that the quantity of water discharged by the river was only ONE-SIXTH of the water that fell over the catchment as rain and snow.

3.3 Edme Mariotte (1620-1684) computed the discharge of the Seine by making velocity measurements by the float method and verified Perrault's results.

3.4 Edmund Halley (1656-1742), an English Astronomer, showed by experiment that moisture evaporated from the surface of the oceans is entirely adequate to supply the water, with rainfall and snowfall, returned as runoff. He demostrated that the evaporation from the Mediterranean Sea is ample to supply the quantity of water returned to that sea by the rivers flowing into it, and thus finally set at naught what the early philosophers held, viz. (*i*) rainfall was totally inadequate to account for the vast flow of waters in rivers like Seine and Nile. (*ii*) the earth's surface was too impervious to allow the percolation of rain water into the soil and rocks from whence it could be returned in the form of springs and that (*iii*) the water rising in springs and flowing to the Ocean in streams could not possible be the runoff from rain and snow.

4. Precipitation and Runoff: their Significance—

4.1. In all engineering problems dealing with storage utilisation or removal of water, the amount of runoff from a catchment and the manner of its distribution are the chief factors upon which the engineering design is based. If the amount of water available is incorrectly estimated, the project will be a failure even though the engineering structures are correctly designed for the conditions as assumed.

4.2. If runoff data were available for all catchments, there should be no particular need for rainfall records. Unfortunately records of runoff are available for comparatively few catchments, and, these also, for short periods of time only. The engineer has, therefore to estimate the runoff essentially from his knowlege of the precipitation. While there is no definite ratio of general application between rainfall and runoff, yet the latter is dependent on the former. A knowledge of precipitation, its amount, occurrence and distribution, therefore, are of primary importance in projects of water supply irrigation, flood-control, drainage and hydro-electric works.

5.1 Rainfall over India and the Bombay State: the phenomenon and the pattern of annual rainfall—The generic term Precipitation includes all moisture that reaches the earth, whatever its form—rain, snow, hail, dew or frost. Free air is seldom perfectly dry: but precipitation can result only when the air containing the moisture is cooled sufficiently to enable part of the moisture to condense: and cooling of air masses may be brought about either by radiation or by lifting. Cooling by radiation is the cause of dew and frost, which are quantitatively unimportant and seldom measured. Cooling by lifting is the cause of rain, snow, sleet and hail. It is not proposed to go here into the subject of artificial rain and rain-making. The lifting may result from topographical conditions, frontal action or convergence or from thermal convection.

5.1.1 In the beginning of June, every year, the winds advancing over the Indian Ocean are saturated with water vapour and form a great reservoir of moist air with huge height above the sea surface. The rush of this air towards the low pressure constitutes the burst of the South-West Monsoon. Its Western branch touches North Kanara, first in Bombay, and then proceeds towards Gujerath being deflected Northwards by the mountain ranges along the West Coast. As it advances, amount of precipitation decreases from South to North along the coast. Bhatkal the extreme South point on the Old Bombay State Coast, receives an annual rainfall of about 150 inches. Ratnagiri, about 200 miles north, receives 90 tp 100 inches, whilst Umbargaon in the north of the Thana District receives only about 60 inches.

5.1.2 On the West Coast of the peninsula, a narrow belt of about 50 miles in width, receives heavy rainfall when the South West Monsoon blows fully on the land adjacent to the Arabian Sea and helps to produce the valuable paddy crop in the Konkan and along the West-Coast.

5. 1, 3 The Sahyadri range of mountains or the Western Ghats, about 1000 miles long, with an average elevation of from 3500 to 4000 feet, but having many peaks rising to over 7000 or 8000 feet, runs almost parallel to the coast. As the high range obstructs the super saturated clouds, they ascend this range to reach the region of lower pressure in the interior. The ascent of air brings about expansion and sudden cooling of the air resulting in heavy precipitation on the ridge of the Sahyadri. That is why places like Bavda and Mahableshwar on the crest of the Western Ghats normally receive as much as 250 inches and more of rain annually. (vide Plate 1). This Zone of high precipitation contracts rapidly to the North of Bombay and disappears at the end of the Ghats, south of Tapi River. Still further north on the coasts of Saurashtra, over Cutch and Sind, although the monsoon wind blows strong, its moisture content is low, and the physical features and configuration of land are not favourable to precipitation. Hence, at Bhuj in Cutch the average annual rainfall is less than 15 inches, and at Karachi in Sind it is only six inches, not to speak of the lowest minimum rainfall at Amreli, which approaches unity at times.

5. 1. 4 Now, to the east of the Western Ghats, the rainfall rapidly decreases as the clouds which pass the Sahyadri range are already depleted of their moisture, having poured the bulk on the mountain crest ; thus, at Gokak about 70 miles east of Bavda, the annual average rainfall is not more than 25 inches, as it falls in the rain-shadow of the Western Ghats and hence receives only a small quantity of rain which diminishes steadily from West to East.

5. 1. 5 The same phenomenon is noticed as we observe the rainfall at Ghatgar, Bhandardara, Rajur, Akola, Sangamner, Shrirampur, and Newasa in the Ahmednagar District, showing a rapid fall in the precipitation as we move from West to East. This is representative of a broad zone extending all down the Peninsula to the east of the Western Ghats, in which the annual rainfall averages from 18 to 25 inches only.

5. 1. 6 Thus there is a vast area in the Peninsular India which receives meagre rainfall and is therefore extremely liable to failure of crops, resulting in scarcity or famine,, being subject to precarious condition. This area forms the plateau comprising of the South-Eastern districts of Bombay, northern districts of Madras and South Western districts both of Andhra Hyderabad and Madras and the eastern portion of Mysore. The total area of these shadow regions is of the order of 75,000 square miles, which receives strong westerly drying winds throughout the South-West Monsoon, blowing at the rate of 30 feet to 70 feet per second.

5. 2. 1 The Bay of Bengal branch of the monsoon is equally important as it serves the extensive areas of the northern and north-eastern India, from the north of Godavari delta to the Himalayas, eastern India and Eastern Pakistan, and from the Eastern boundary of Assam to the western and northern boundaries of West Pakistan. It gives ample rain to West Bengal making about 50 to 55 inches from June to September and thus makes the Bengal State one of the largest producers of rice in India, most of its rice being obtained from the Aman Crop which is sown in June and harvested about November. Same can be said of Bihar.

5.2.2 The current which strikes from Southern direction at the head of the Bay of Bengal, being deflected towards north by the Arakan ranges, takes a turn to the west along the foot of the Himalayas. To the north of the Gangetic delta, the Cyclones strike the high mountain ranges at right angles and are forced up the ascent, resulting in the heaviest precipitation at Cherrapunji, known for its highest rainfall in the world, averaging 450 inches per year, the maximum recorded being 905 inches in 1861, this place being situated on the high escarpment of the Khasi hills in the Himalayas, in Assam.

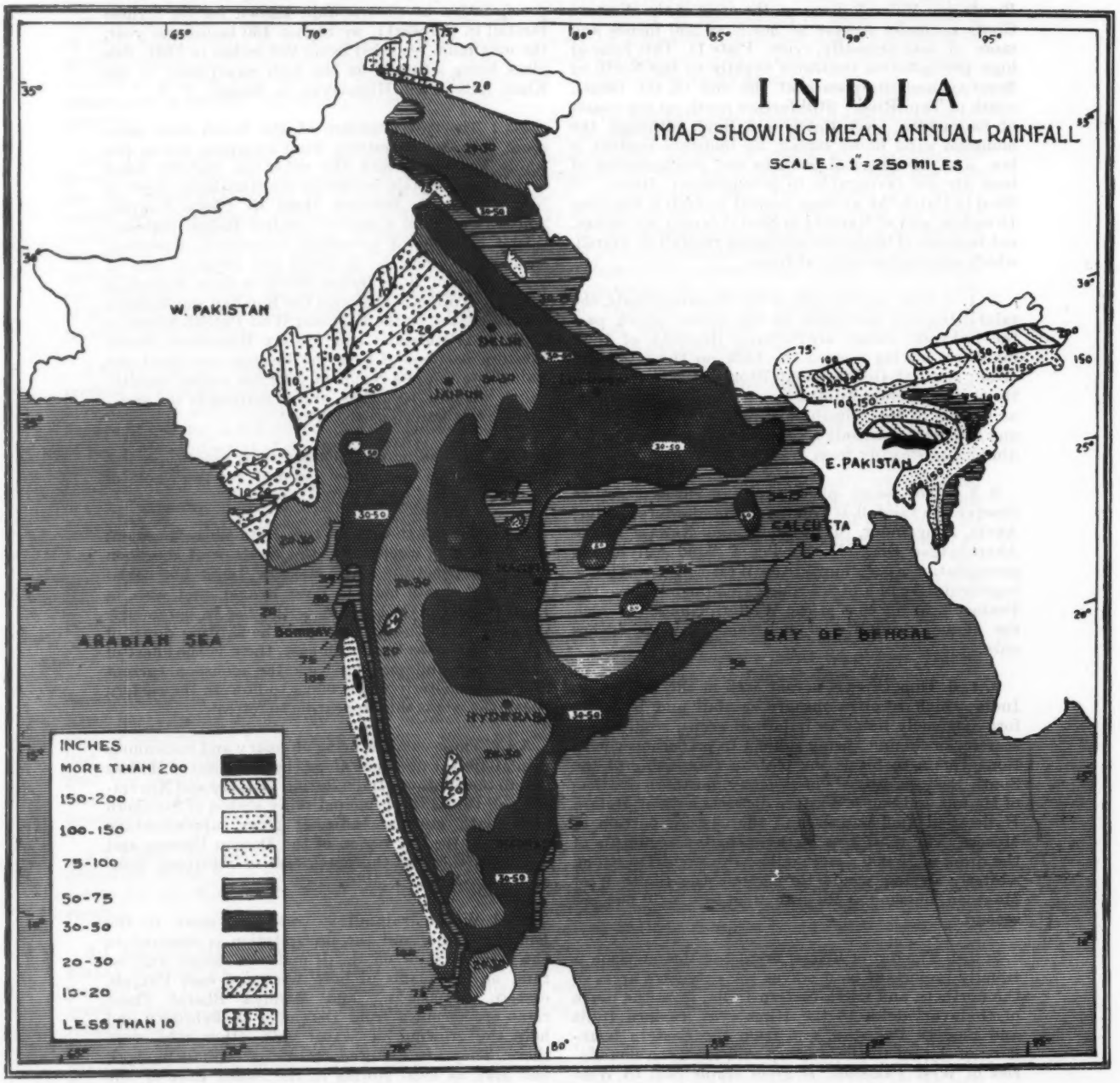
5.3.1 The two branches of the South-west monsoon, the one a westerly wind sweeping across the whole Peninsula, and the other an easterly wind occupying the plain bordering the Himalayas, meet in Northern India. Between them lie Chota Nagpur, South Bihar, and a part of Central Indian plateau ; this is the area of persistent barometric depression throughout monsoon. A broad and irregular belt of low rainfall of 20-30 inches stretches from Madras in a northern direction through the Bombay and Madhya Bharat States, to the East and West Pubjab States in India and Pakistan ; and western Rajasthan, South Western portions of both the Punjabs and Sind and Baluchistan form a region of very low annual rainfall, which is below 10 inches, and it surrounds the semi-desert tract known as the 'Thar'.

5.3.2 Thus the most important rainy season operates from June to September, almost for the whole of India.

5.4.1 The north-east or the Returning Monsoon: By the end of September, the South-west monsoon ceases to penetrate north-western India but continues for a month more in West Bengal, and, also, in East Pakistan. On account of the rise in barometric pressure in northern India and the shifting down of the depression to the South-east, there is the effect of obstructing and pushing back the monsoon current and north-easterly winds being to flow on the eastern coast, the winds thus appearing to retreat.

5.4.2 These changes bring on heavy and continuous rainfall for the first time along the east coast of Madras and to the Southern India during October and November and this is the principal rainy season of Southern and South Eastern India. It gives supplementary rainfall to the dry region of the Deccan Plateau and is known there as the north-east or returning monsoon.

5.5.1 Winter rainfall is restricted more to the northern-India and the precipitation is received in the form of snow on the Himalayan ranges and, as rain, on the plains of both west and east Punjab, eastern Rajasthan, and Madhya Bharat. These rains are received from December to February and help the growing of wheat and other rabi crops there. They are followed by spring rainfall in April and May as local storms in the South East of the Peninsula and in Bengal especially on and around the hills. Western India including the dry plateau of the Bombay-Daccan, does not, generally, receive these rains.


INDIA
MAP SHOWING MEAN ANNUAL RAINFALL
SCALE - 1" = 250 MILES
W. PAKISTAN
E. PAKISTAN
DELHI
JAIPUR
CALCUTTA
BOMBAY
HYDERABAD
ARABIAN SEA
BAY OF BENGAL
INCHES
MORE THAN 200
150-200
100-150
75-100
50-75
30-50
20-30
10-20
LESS THAN 10

## Part II

6. Gauging Work : Rain-gauging work. This is described under the following sub-sections 6-1 to 6-18.

6.1.1 Necessity and importance of Rain Gauging Work. Success of the River valley projects largely depends on sound planning and correct scientific designing and proper phasing, which essentially need adequate hydrological data. Valleys are not all alike ; even sub-valleys of a main river valley are widely dissimilar Koyna and Yerala the subvalleys of Krishna, or Yel and Bhama the subvalleys fo the Bhima basin can aptly be cited as instances. Each valley has its own features and characteristics and needs to be studied in detail regarding topography, lands, strata, climate, seasons, rainfall and other hydrological features.

6.1.2 Adequate hydrological data at the disposal of the engineer entrusted with the design of River Valley Projects enables him to produce well-designed Reservoirs and other appertenant structures. Otherwise, too large structures entailing waste of funds or too small works or inadequate wasteweirs involving danger of damage or necessity of immediate modifications entailing high costs, would result.

6.1.3 India and even Bombay State covers areas with wide range of precipitation, variety of catchments soils and climatic conditions which necessitates construction of large number of works and providing for the collection of appropriate hydrological data for each of them.

6.1.4 Gauging work has thus to be assigned a very high priority, at least from now onwards, to provide full and abundant hydrological data for all future projects.

6.1.5 It would seem to be the crux of responsibility of the organisation concerned to see that gauging is done properly, adequately and in a thorough manner : and continuity is the soul of guaging. Discontinuous data is not of much avail. A Statewise master-plan would be highly useful, if a definite policy be laid down and requisite funds also allotted every year.

6.2.1 Progress done so far in the Bombay State : Records show that discharges of some tributaries of the Krishna Valley are available since 1887. Precipitation data of some stations of the Bombay state is available from 1875. The Irrigation Commission of 1901-1903 truly laid the foundation of Irrigation Development activities ; and at the instance of the Government of India, Bombay Government deputed Mr. Beale as Superintendent Engineer on Special Duty, to investigate important river valleys and report on the most feasible Projects with Reservoir Sites and Irrigation Canals.

6 2.2 Work done by Beale and Hill. Mr Beale got organised the survey parties under Executive Engineers on Special Duties and started observations and reporting of monthly and annual discharges of rivers and streams and established new rainfall recording stations, for observation, recording and reporting of the rainfall at the various representative and typical places in each valley. Where monthly seasonal and annual discharges of streams were already available for a number of years, as in the case of Ghataprabha, full use of the data was made; but where no such discharge observations were available, same were started at or above prospective storage-reservoir sites, with a view to ascertain likely quantity of flood water in bad, good, and average years, and determine safe capacities for the proposed Storage-Reservoir to be provided at the head of the proposed Irrigation Scheme to feed the canals dependent on same.

6.2.3 From the data collected by his organisation Mr. Beale prepared and submitted in 1909, the preliminary report on the Surveys for most feasible schemes to be proposed as protective Irrigation Works in the Deccan, and Mr. Hill as Chief Engineer wrote his masterly Review.

6.2.4 Gauging activity can be said to have been steady from 1902 to 1926 : but, due to general slump and consequent shortage of funds, if not of trained personnel, the activity was suspended and remained so till 1946. But it was ordered to be resumed since 1945-46, and during the last ten years or so, eighty (80) river gauges and one hundred and sixty (160) rain gauges have been established in the Deccan Region of the Bombay State. Revised Programme of installing new gauges contemplates establishing of seven (7) river gauges and twenty five (25) rain-gauges every year.

6.2.5 Valley Reports : Valley Reports have been prepared from April 1948 to January 1950 for the Valleys of Bhima, Godavari, Tapti (Tapi), Krishna, Narmada, Sabarmati, Mahi and Tungabhadra Rivers. They can be considered as pilot surveys of the hydrological potential of each valley.

6.2.6 With the formation of the two Statutory bodies viz. (*i*) the Central Board of Irrigation and (*ii*) the Central Water and Power Commission, which are keen on the development of River Valleys, great incentive has been given to gauging work and the new Central India and Deccan Rivers Circle with its head quarters at Hyderabad, has been assigned the expanding of gauging activities also.

6.3 Details of the job of gauging :

6.3.1 The Field-Work : The Field Work comprises of :—

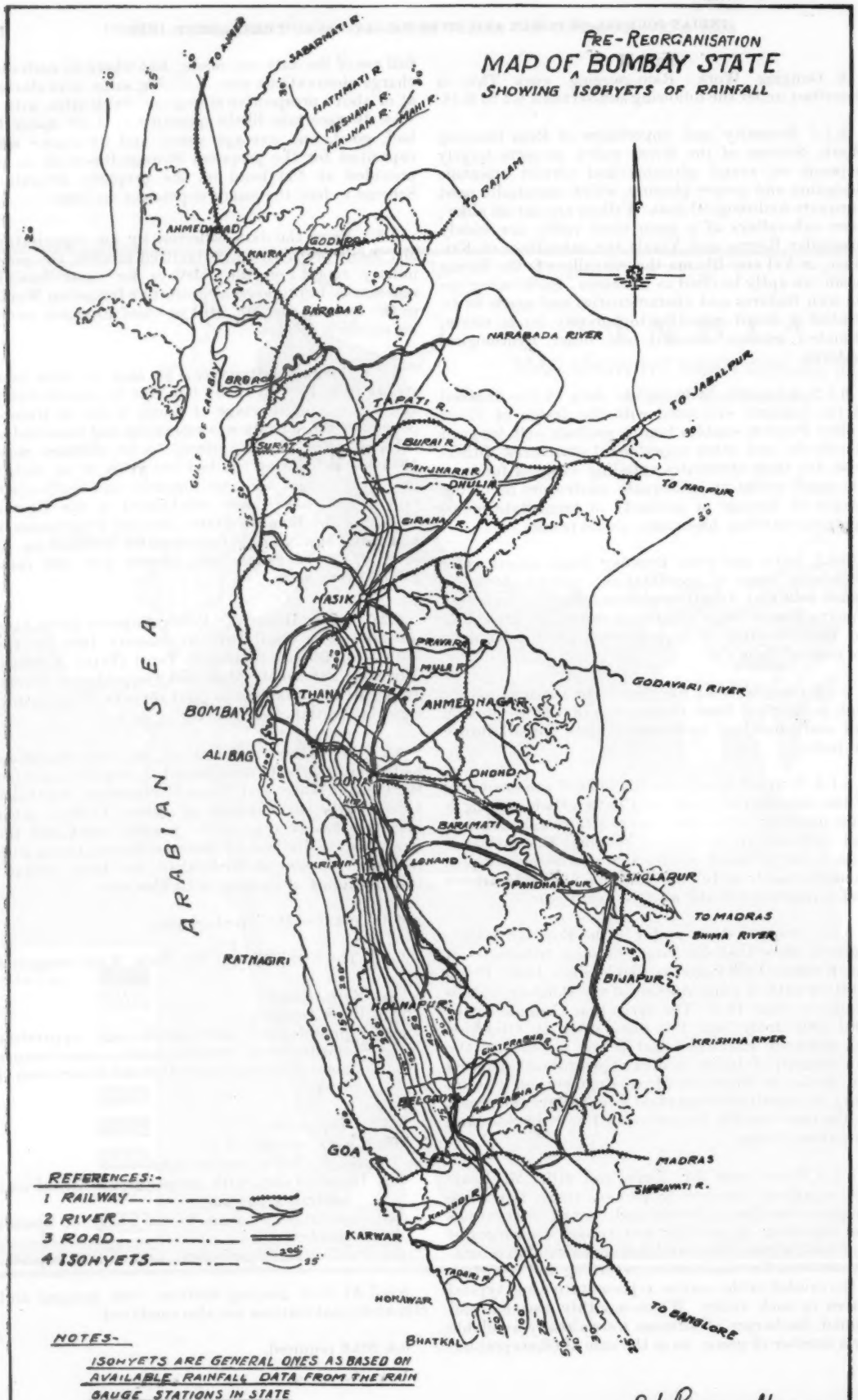
(*i*) Rain Gauging
(*ii*) River Gauging
(*iii*) Climatological instruments and apparatus, construction, establishments, maintenance and repairs and inspection and supervision of works.

6.3.2 Office work :
Office work consists of :
(*i*) compilation of various data,
(*ii*) Digest of data with graphical, statistical and analysis study and
(*iii*) application of same to the study of special problems
(*iv*) Publication of periodical, and annual reports.

6.3.3 At river gauging stations, rain gauging and climatological stations are also combined.

6.4 Staff required.

PLATE 2


PRE-REORGANISATION
MAP OF BOMBAY STATE
SHOWING ISOHYETS OF RAINFALL
TO AJMER
SABARMATI R.
HATHMATI R.
MESHWA R.
MAHI R.
MAHAM R.
TO RATLAM
AHMEDABAD
KAIRA
GODHERA
BARODA R.
NARABADA RIVER
BROACH
GULF OF CAMBAY
TAPATI R.
TO JABALPUR
SURAT
BURAI R.
PANJHARA R.
DHULIA
TO NAGPUR
GIRANA R.
NASIK
PRAVARA R.
MULA R.
GODAVARI RIVER
THANA
AHMEDNAGAR
BOMBAY
ALIBAG
POONA
CHOND
BARAMATI
KRISHNA R.
LONAND
PANDHARPUR
SHOLAPUR
TO MADRAS
BHIMA RIVER
RATNAGIRI
BIJAPUR
KOLHAPUR
KRISHNA RIVER
GHATPRABHA R.
BELGAUM
MALPRABHA R.
GOA
MADRAS
SHARAVATI R.
KARWAR
TADRI R.
HONAWAR
TO BANGLORE
BHATKAL
ARABIAN SEA
REFERENCES:-
1 RAILWAY
2 RIVER
3 ROAD
4 ISOHYETS
NOTES-
ISOHYETS ARE GENERAL ONES AS BASED ON AVAILABLE RAINFALL DATA FROM THE RAIN GAUGE STATIONS IN STATE
R.L. Phansalkar

6.4.1 Rain Gauges : Usually a part time rain gauge reader for observing gauges in difficult and isolated situations like Bhimashankar or Harishchandragad, is engaged. He is helped during rains by a Khalasi for affording postal facilities also.

6.4.2 River Gauge Stations : The staff comprises of (*a*) Gauge Karkun. (*b*) Gauge Khalasis and (*c*) Boatmen. An ordinary gauge on a river of medium size has only one gauge Karkun and one Khalasi ; In the case of bigger rivers, two or more khalasis are required to help the gauge karkun. Boats are provided in the case of big perennial rivers and they are manned by boatmen and khalasis.

6.4.3 Climatological Stations : No separate observer is engaged. The rain gauge reader or the river gauge karkun himself takes these observations, in addition to his own duties.

6.4.4 The job requires patience, perseverance, sincerity, accuracy and aptitude for research and necessary knowledge. During monsoon the job of the gauge karkun is risky and very trying, particularly during floods.

6.5 Record : The initial documents are prepared by the gauging staff by noting down all the daily observations in the various prescribed forms. Copies of these are sent by them to their officers who are responsible for the compilation digest and study of same.

6.5.1 A number of rain and river gauges and climatological stations are placed in-charge of a Sectional Officer and four such Sectional Officers are working under one Deputy Engineer who is attached to the Division. Touring involved for the inspection of gauges and supervision of the gauging work is tedious and irksome. Office work is equally important and requires persons of right type for compilation, digest and interpretation of the data ; aptitude and sustained interest alone can make this job helpful in the building up of reliable and informative records and intelligent and useful reports.

6.6 Rain Gauging : Its usefulness :
It is required for ascertaining the amount of precipitation the length of its duration and the intensity of the same at the place. Rain gauges located at proper places help to ascertain the details of total precipitation over a subvalley or a valley area. From this data, the water-potential can be estimated and detailed studies of storms, including analysis and unitgraphs can be undertaken.

6.7 Number of Rain Guages required ; Due to the vagaries of monsoon, from place to place, and wide dissimilarites of the valleys, it is most essential to have adequate number of gauges all over the valley. In the U.S.A. 8000 non-recording and 3,000 recording gauges existed in 1952, with about one guage per 275 sq. miles. In India, there were, in 1949, about 2700 rain-gauges over an area of 11.4 lakhs of sq. miles i.e. at the rate of 1 per 422 sq. miles. The Bombay State, presumably due to earlier start of this activity here, has 405 rain gauges in the catchment area of about 82,000 sq. miles which works to one gauge per 202 sq. miles. More rain gauges have so far been established in the hilly tracts of the Sahyadri. Rain gauges are essentially required in areas above the isohyets of 30 inches of rainfall (Vide plate 2) and also at important locations such as mountain summits, windward sides and also lee-ward sides of hills, foot of hill-ranges and the centre of high table lands and of low planes.

6.7.1. The Inspector General of Irrigation expressed in 1906 that the following would be the minimum scale for the number of stations required to enable a reasonably safe estimate of rainfall being made :—

TABLE NO. 1

| *Catchment area in Sq. miles.* | *Average C.A. Sq. miles.* | *Nos. of Rain-Gauges* | *Nos. of Stations per 100 Sq. miles.* |
|---|---|---|---|
| 0 to 50 | 25 | 1 | 4.00 |
| 50 to 100 | 75 | 2 | 2.70 |
| 100 to 200 | 150 | 3 | 2.00 |
| 200 to 350 | 275 | 4 | 1.45 |
| 350 to 500 | 425 | 5 | 1.18 |
| 500 to 700 | 600 | 6 | 1.00 |

6.7.2 The British Water-Works Engineers prefer to have one rain gauge for every 1,000 acres of catchment, or, 64 numbers per 100 sq. miles.

6.7.3 Considering the sudden drop-down in rainfall as we move eastward from the Ghats, in the rain-shadow-region, and the wide monthly and daily fluctuations, for the Deccan conditions the following scale is suggested :—

| | |
|---|---|
| 1 On the top portions and along the steep slopes of the Sahyadri Hills with rainfall from 265″ to 50″ | 15 Nos. per 100 sq. miles of Catchment area. |
| 2. On side-long gentle slopes of hills and in planes with rainfall varying from 50″ to 30″ | 10 Nos. per 100 sq. miles, of catchment area. |
| 3. On undulating and plain country with rainfall varying from 30″ to 20″ | 5 Nos. per 100 sq. miles of catchment area. |
| 4. For areas with a rainfall of below 20″ | 2 Nos. per 100 sq. miles of area. |

6.7.4 As regards the four major valleys of the Tapi, Godavari, Bhima and Krishna, the required number of Rain-Gauges works to 3600 dos or more, while the existing number of gauges is only 405 (four hundred and five) nos.

6.7.5 It is therefore of paramount importance that adequate number of rain-gauge stations are establi-

shed in the State, soon bringing their number to the required strength, as this would be the first material step towards the development of the river-valleys, which are often suffering heavily due to scarcity and the ravages of famines—which used to be more frequent before.

6.7.6 There are many districts in the Bombay State, which, being famine-stricken, require immediate examination of rivervalleys in such areas. Postponing by even a single year, of such examination, would mean delay in taking adequate measures by constructing irrigation works—major, medium or minor, as the case may be—which in its turn means the State would lose heavily and rapidly due to the onslaught of Scarcity and famine ; while, on the other hand, early construction of irrigation works would bring relief and give solace to the populace by solving the problem of recurring scarcity conditions and dreadful famines, in areas, with precarious rainfall and majority of agricultural population.

6.8 The Cost : The cost of installation of one Rain Gauge is Rs. 250 to Rs. 300. The I.D. Division during the author's incumbency had kept the target of installing twentyfive (25) rain-gauges annually in addition to seven (7) river-gauges in the available funds. Although the original target was of fixing seventy-two (72) rain-gauges and thirty-six (36) river-gauges annually.

6.8 1 The total cost of installing adequate number of rain-gauges works to a fairly high figure; but, considering that would enable collection of adequate data of great value, which would help proper planning and location of storages and tanks and correct designing of their storage capacity and spillways, in the large precarious area in the east and south-east of the Bombay State, for affording permanent relief to agriculturists there, the negligible expenditure involved, would be more than repaid, by the proper planning and designing of irrigation schemes being made practicable.

6.9 Suggestions for locating new Rain-Gauges: Provision should be made in future projects for establishing rain-gauges at dam-sites and a number over the catchment area and also along the canal, at the headquarters of staff, and within the premises of inspection bungalows and at other suitable places.

6.9.1 Data from these can be utilised in establishing Runoff Coefficient for each individual catchment after computing the total runoff produced by the respective catchment and total precipitation over the catchment; such correlation between the precipitation in the valley and the runoff of the stream concerned, would not be possible if the number of rain gauges, from which the average precipitation in the valley area under observation could be calculated, is inadequate.

6.10 Working Cost: Cost of manning and maintenance of the gauges no doubt works rather high. Other Government Departments and private institutions and industrial companies can be persuaded to direct their staff to give regular part-time service, with suitable extra remuneration to be paid by Government. Shri R F Boga, I. A. S., as the collector of Sholapur, had willingly agreed to manage the observation of a few Rain-Gauges in the Sholapur District, through the agency of his Circle Officers: and on obtaining the necessary approval, the writer got three new rain gauges fixed in March 1955, at the headquarters of the circle officers, in that district.

6.11 Period of observation: It is most desirable to have rain gauges observed for all the year round. School teachers are paid an allowance of Rs. 15/- p.m., and local persons Rs. 45/- p. m., when engaged as rain gauge readers. To keep down the cost, that would otherwise mount high, observations are taken, here, in the Deccan, for a period of seven months, only from 1st June to 31st December, every year. Insufficiency of funds limits this period to five months viz. from 1st June to 31 st October only. Following table will show that it is highly necessary to observe for seven months, though observing for five months just serves the purpose generally.

Table NO. 2.

Details based on the Rainfall figures for 1952-53.

| *S. No.* | *Name of valley* | *Percentage of Rainfall during each of the months during* 1952. | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Jun.* | *Jul.* | *Aug.* | *Sept.* | *Oct.* | *Nov. & Dec.* |
| 1. | Tapi | 22 | 46 | 18 | 13 | 1 | Negligible. |
| 2. | Godavari | 19 | 50 | 24 | 3 | 4 | -do- |
| 3. | Bhima | 17 | 45 | 29 | 4 | 5 | -do- |
| 4. | Krishna | 15 | 48 | 20 | 6 | 11 | -do- |

6.2 Installation of Self Recording Rain Gauges: It would be desirable to have about 10% of the rain-gauge stations equipped with self-recording rain-gauges. At each station having annual precipitation above 100 inches, it is very necessary to instal a S. R. Rainguage.

6.12.1 Manufacture of S. R. Raingauges. The S. R. Raingauges prepared by the Meteorological Department are now being used. These are of syphon type. The holding capacity of the syphon was previously only 40 cents and that of the clock was 24 hours. They are alright provided reading is taken daily and paper replaced. For out-of-the-way places, instruments having 100 cents syphon-capacity and seven-days clock-capacity, were manufactured and same are found to be giving useful service.

6.13 Rain-Gauge Site: Usually a small plot of land 10 ft. by 10 ft. from Government waste or barren land is selected to avoid land acquisition and also to get the gauge fixed without delay. In selecting sites in hilly tracts, experience is necessary so that the rain gauge can be so located as to make it truly representative of the area it commands.

6.14 Rain gauge observation assigned to a Social Worker: Work of observing rain gauges in a locality, near Rajgad, in the Poona District, was entrusted during 1954-55 and 1955-56 to persons working under the guidance of a retired engineer and now a social worker. Nine rain-gauges were assigned to this group for observation with a remuneration of Rs. 10 p. m. per gauge. The work was very satisfactory entirely due to the keen interest, tremendous energy and zeal

and personal guidance of veteran Professor S. R. Bhagwat, L.C.E., a Retired P. W. D. Engineer and ex-Chief Officer of the Poona City Corporation; Otherwise, it is not possible to obtain, punctually, accurate and dependabe data from private agencies, at such a moderate cost.

6.15. Other Requirements. Whenever any new staff is engaged at the rain gauge station, it is necessary to arrange a few lectures and a demonstration pertaining to the rain-gauging work to ensure efficient work being obtained. In respect of observers stationed in mountains and rainy tracts and at places like Ghatghar (Pravara) Bhimashankar (Bhima) or Mahabaleshwar (Krishna), it is very necessary to provide them with water-proof bags, rain-coats and umbrellas.

6.16 Sources of Error in Observations. The writer observed that the following are he main sources of error.

1. Wrong Site: The gauge may record rain much higher or lower than the correct actual. Careful study and changing of the location is necessary in such cases.

2. Blocking up of funnel or spout hole, with leaves twigs etc.

3. Spilling of water while taking it out from the raingauge for measuring.

4. Inaccurate measurement or mistake in reading and recording 0.05″ and 0.5″ etc.

5. Leaky funnel or leaky container from which rain drops are lost.

6. Lack or precautions while measuring during a downpour.

7. Flood water from nallas may enter the gauge and give a wrong record of the rain.

6.17 Period of maintenance: A Raingauge once fixed is good for ever and has to be maintained and observed for all time, unless and until, it is discontinued after the construction of another rain gauge nearby, at a better site. Perpetual observation is necessary to have a continuous record and to enable the establishing of the rainfall cycle — if there be one—and estimate the water-potential of the tract.

6.18 Progress of Work: Recording and Compilation of Data. Compilation work requires technical scrutiny of observation sheets and arithmetical checking of all the velocity and discharge statements, and periodical, monthly, and annual abstracts. After that is done, the data is entered in the respective Registers, for being included in the Annual Reports. Data collected upto 1926 is already published. The work of gauging and collection of the data was, as already noted, suspended since 1926 to 1945, and hence no data is available for that period. Data collected from 1946 to 1951 is compiled in a typed report: similar reports are nearly complete for the years 1952-53 and 1953-54 and these are to be duly published, in the forms approved by the Central Board of Irrigation and Power.

6.18.1 Rainfall data for 1952-53 with abstracts for all the valleys has been published with necessary analysis in the I. D. D's Annual Report No.20 (vide S.No. 4. in the Bibliography).

6.18.2 Rainfall data for all the I.D.D. Stations along with that for other stations, detailed below is supplied to the Statistician to the Agricultural Department for publication:—

| | | |
|---|---|---|
| (*i*) | I. D. D. Stations | 136 Nos. |
| (*ii*) | Other P. W. D. Stations | 228 Nos. |
| (*iii*) | Revenue Department -do- | 15 Nos. |
| (*iv*) | Medical Officers (including D. L. B. guages) -do- | 2 Nos. |
| (*v*) | Municipalities' -do- | 3 Nos. |
| (*vi*) | Andhra Valley Power Supply Co's -do- | 6 Nos. |
| (*vii*) | Tata Hydro-Electric works' -do- | 6 Nos. |
| (*viii*) | Tata Power Companies' -do- | 7 Nos. |
| (*ix*) | Sugar factories' -do- | 2 Nos. |
| | | 405 Nos. |

## SCHEMES FOR IRRIGATION AND DRAINAGE IN BIHAR OVER ONE LAKH ACRES TO BE IRRIGATED

Twentyfour schemes for irrigation and drainage have so far been sanctioned by the Government of India under a special programme for "permanent improvement of scarcity areas" in Bihar.

Two of these schemes, which relate to irrigation, are for extension on the Kamla and Triveni canals. On completion of the canals, a total area of 1,02,100 acres of land is expected to be brought under irrigation.

The Kamla canal will benefit an area of 40,000 acres in the Darbhanga district and the Triveni canal 62,100 acres in the Champaran district of the State.

The irrigation schemes are estimated to cost Rs.138 lakhs, and are being continued from the first Five-Year Plan period.

The 22 drainage schemes aim at opening up the outflow of storm water from the areas which remain submerged during the monsoon, thereby reclaiming additional land for cultivation.

The total allocation for the schemes is Rs. 350 lakhs. of which Rs. 225.38 lakhs have so far been sanctioned by the Government of India as loans to the Bihar Government.

For the current year, the allocation is Rs. 20 lakhs.

# St. Lawrence Seaway Project: An Outline

The St. Lawrence Seaway is essentially a water highway from the sea to the heartland of North America. Since the days of the first half of the 16th Century when the explorer Jacques Cartier was turned back by the rushing waters of the Lachine Rapids from his dream of finding the Northwest Passage and the route to the rich and glamorous East, men have devoted their thoughts and their works to the building of a deep waterway from the Atlantic Ocean into the great inland lakes. Today, but for a small portion, this dream has been realized.

There remains however a 14-foot bottleneck between Montreal and Prescott which must be removed and the provision of deeper channels between Lake Ontario and Lake Erie to allow 27-foot navigation throughout the St. Lawrence.

To provide this navigational facility is a mighty task and for its accomplishment and future operation the St. Lawrence Seaway Authority was consituted.

The St. Lawrence Seaway Authority, a Crown Corporation, was established by Act of Parliament in December, 1951. The Act was proclaimed and the appointment of its members made public on July 1, 1954.

The Authority is incorporated for the purpose of:

(*a*) Acquiring lands for and constructing, maintaining and operating all such works as may be necessary to provide and maintain, either wholly in Canada or in conjunction with works undertaken by an appropriate authority in the United States, a deep waterway between the Port of Montreal and Lake Erie;

(*b*) Constructing, maintaining and operating all such works in connection with such a deep waterway as the Governor in Council may deem necessary to fulfill any obligation undertaken by Canada pursuant to any present or future agreement.

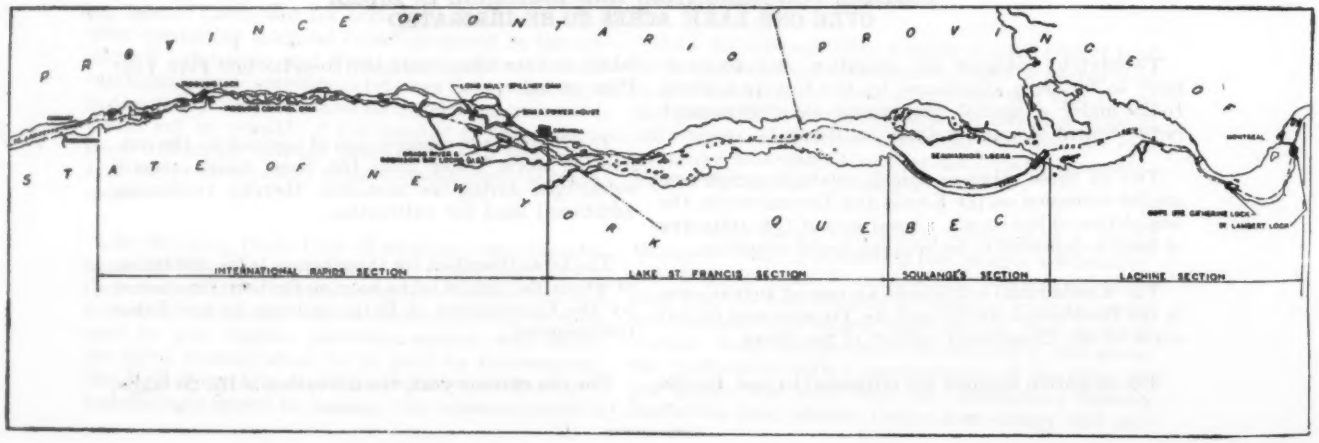
## Historical Notes

*Lachine Canal*

The first recorded improvement in the long history of navigation on the St. Lawrence waterway dates back to 1700, when a one-and-a-half-foot canal was constructed at the Little River St. Pierre near Lachine.

In 1780 and 1804 short side canals having two to three feet in depth were constructed at the edge of the rapids. Using them were, among other craft, the huge freight-carrying "canots de maitre" of the fur-trading

**Plan of the Seaway Project.**



**Saunders-St. Lawrence Hydro Power Station under construction**

companies as they plied between their base at Montreal and the remote posts of the West.

It was only in 1821 that the first Lachine Canal proper was undertaken. From a five-foot depth this canal was deepened to 9 feet between 1843 and 1848. A second and last enlargement, between 1870 and 1883, provided a 14-foot depth throughout. This Lachine Canal, now eight and three-quarter miles long, has a total lift of 50 feet and gives access from the Port of Montreal to Lake St. Louis, that widening in the St. Lawrence River which is increased by the confluence with the Ottawa River from the North and West.

*Soulanges and Beauharnois Canals*

The Soulanges Section extends from deep water at the head of Lake St. Louis to deep water at the foot of Lake St. Francis, another widening in the course of the St. Lawrence.

Between 1779 and 1783, the Royal Engineers constructed four side canals with locks six feet wide, giving two-and-one-half-foot depth to overcome the Cascades, Split Rock, Cedars and Coteau Rapids, in ascending order.

The Beauharnois Canal, on the southerly shore, built between 1842 and 1845, replaced these earlier canals and provided 9-foot navigation. It, in turn, was replaced by the present Soulanges Canal on the opposite side of the river, begun in 1892 and completed in 1899. It has five locks, a total lift of 84 feet and provides 14-foot navigation.

The power canal at Beauharnois for hydro-electric development completed in 1932 was built with the design to give a 27-foot channel and now awaits the completion of necessary locks and other navigation essentials to provide the deep waterway through this section of the river.

*International Rapids section*

The International Rapids Section extends from St. Regis at the head of Lake St. Francis to Chimney Point, East of Prescott. It has a total difference of

water level of some 92 feet and this is overcome by a series of canals.

The first of these, proceeding up-river, is at Cornwall, where a nine-foot canal was built between 1834 and 1842. In turn this canal was enlarged to 14 foot depth between 1876 and 1900.

Next in order is the Farran's Point Canal, first built between 1844 and 1847 and enlarged to 14 foot depth between 1897 and 1901.

The Rapide Plat Canal at Morrisburg, constructed at the same time as the canal at Farran's Point, was enlarged to provide 14-foot draught between 1884 and 1904.

The last in the series of canals in this section is the Galop Canal at Iroquois. Construction of this canal for 9-foot navigation commenced in 1844 and was completed in 1848. This canal was later enlarged to 14 foot depth and completed in 1908.

*Welland Ship Canal*

The obstacle to navigation between Lake Ontario and Lake Erie is presented by the Niagara River, its rapids and Niagara Falls. Between the lakes there is a difference in level of 326 feet. This is overcome by the Welland Ship Canal, which crosses the Niagara Peninsula 10 miles west of Niagara Falls. It is some 27 miles in length.

The first canal here was bult by a private company between 1824 and 1833 and had a depth of seven-and-a-half feet. This canal was later taken over by the Government of Upper Canada and enlarged to 9 foot between 1842 and 1850. Its completion coincided with the completion of the St. Lawrence Canals in 1848 and permitted vessels 140 feet long, of 26-foot beam and nine foot draught to ascend for the first time from Montreal to Lake Erie. Construction of the third Welland Canal was begun about 1873 and completed for 14-foot navigation in 1887. It required no less than 26 locks to accomplish the 326-foot lift from Lake Ontario to Lake Erie.

In 1913 work was begun on the Welland Ship Canal. Construction was suspended in the Fall of 1916 due to World War I but was resumed after the cessation of hostilities and completed in 1932.

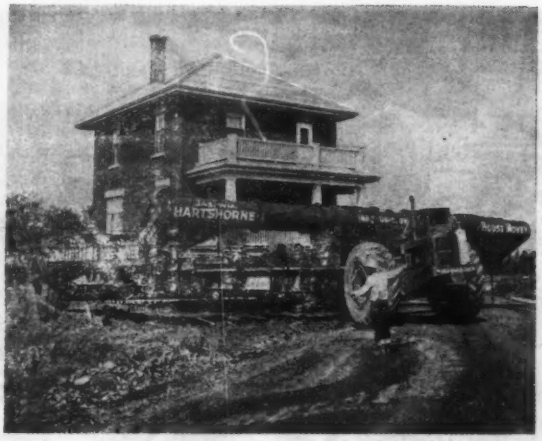
The lift from lake to lake is the same as by the old canal but is accomplished with only eight locks as against 26 in the 14-foot canal.

Seven of these eight locks are 859 feet long and one is 1,380 feet in length. All are 80 feet wide with 30-foot depth over the lock sills.

The present available depth is 25 feet although about 17 miles of the canal have a draught of 27 feet. Dredging will bring the entire canal to a 27 foot depth.

**International Negotiations**

Although the subject had been considered for over a century, the first concerted action of the Governments of Canada and the United States in connection with a deep waterway from the Great Lakes to the sea may be said to date at least as far back as 1905. Then a joint International Waterways Commission was




**A Brick House on a Mover.**

created to deal with all matters relating to international waters between Canada and the United States.

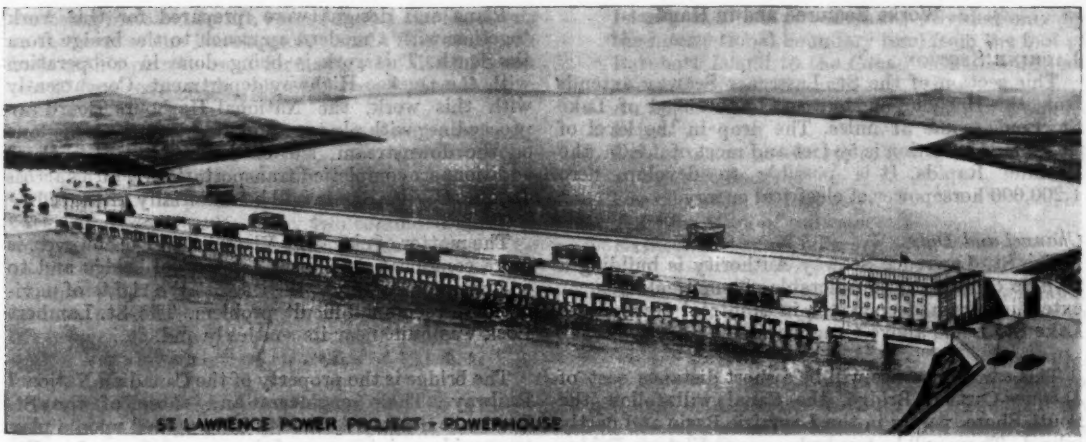
Negotiations were begun and continued over the years with the end in view of finally establishing a deep waterway throughout the whole St. Lawrence Basin.

No subject has been more thoroughly discussed, none more carefully studied. All of these studies culminated in first, the Treaty of Washington signed between Canada and the United States in 1932 which was *not* approved by the United States Senate. Next followed the Great Lakes St. Lawrence Basin Agreement of 1941 concerning a deep waterway from Montreal to the head of the Great Lakes. This Agreement failed to receive the approval of the United States Congress.

After ten years without progress because of the failure to get approval of the Agreement and because of further development of hydro-electric power in Southern Ontario became of considerable importance to Canada (and also to the United States), a new approach was adopted by Canada. The first step was the conclusion of an agreement in December 1951 between the Governments of Canada and Ontario. This agreement provided for the construction of the seaway by the Federal Government of Canada and for the development of power in the International Rapids Section by Ontario and an entity to be designated by the United States.

The next step was to secure the approval of the Canadian Parliament for this agreement and legislation to provide for the construction of the seaway. Parliament approved the agreement and enacted legislation for the establishment of the St. Lawrence Seaway Authority in December 1951.

The third step resulted, in June 1952, in agreement between Canada and the United States whereby both countries would join in asking the International Joint Commission (which has jurisdiction over these boundary waters of the International Rapids Section) to approve the joint development of power in that Section by the Hydro Electric Power Commission of Ontario and a power entity to be named by the United States. It was understood that Canada would




**St. Lawrence Power House : Architect's Perspective**

build all the navigation facilities on the Canadian side between Montreal and Lake Erie to provide for 27 foot navigation. The International Joint Commission approved this power project on October 29, 1952.

In June, 1955, the United States Federal Power Commission issued an order granting a 50-year licence to the Power Authority of the State of New York for the development of the United States half of the power project in the International Rapids Section in conjunction with Ontario Hydro.

This did not constitute the final authority to construct the joint power project because the Federal Power Commission's order was challenged in the United States Courts by opponents of the project. The United States Courts by opponents of the project. The United States Supreme Court, in June 1954, upheld the action of the Federal Power Commission in granting a licence to the Power Authority of the State of New York. This decision enabled the power entities to undertake construction of thier project. By the construction of the power project, a lake would be created in the International Section, which would allow the construction of the seaway.

In the meantime, however, the United States Congress enacted the Wiley-Dondero Act authorizing and directing the Saint Lawrence Seaway Development Corporation to construct on United States territory all the navigation facilities in the International Rapids Section.

The situation thereby created called for discussions between Canadian and United States representatives to determine how the seaway would be built. In the final analysis, the United States decided to build a canal and two locks opposite Barnhart Island in the International Rapids Section and to do dredging in the Thousand Islands Section. Canada decided to build a lock and canal near Iroquois in the International Rapids Section in addition to completing all the necessary navigation facilities in Canadian territory between the Port of Montreal and Lake Erie. The estimated costs of the United States works are about $135 million while the estimated costs of the Canadian works are about $300 million.

Work was begun on the power project in August 1954. Thereafter it was possible to start work on the seaway. The preliminary works on the Canadian side were undertaken in September 1954.

### Present Facilities for Navigation

Under present conditions, and as they will remain until the completion of the St. Lawrence Seaway—scheduled to be ready for the opening of the navigation season of 1959—shipping moves by the follow ing navigational facilities :

1. From the Atlantic Ocean to Montreal and in that Port and at its wharves there is maintained a depth of water of 35 feet. A deep-water ship channel to that depth is dredged and maintained from a point 30 miles below Quebec City to Montreal.
2. From Montreal, via the Lachine Canal, Lake St. Louis, the Soulanges Canal, Lake St. Francis, the Cornwall Canal, the Farran's Point Canal, the Rapid Plat or Morrisburg Canal and the Galop Canal to a point four miles below Prescott, Ontario, the governing depth is 14 feet. (In July, 1958 flooding of the area between Cornwall and Iroquois will terminate use of Farran's Point, Morrisburg and Galop Canals and a portion of the Cornwall Canal. Navigation at canal draught will be handled by the Ironquois, Snell and Eisenhower Locks and new channels).
3. From just below Prescott, Ontario, through the Thousand Islands Section of the St. Lawrence River to deep water in Lake Ontario, there are maintained channels which give a depth of water of 25 feet.
4. From Lake ontario the Lake Erie, via the 27-mile Welland Ship Canal, the present available depth of water is 25 feet.
5. From Lake Erie to the Head of the Lakes, there are maintained channels which give a depth of water of 25 feet for downbound vessels and 21 feet for upbound vessels.

In the giant steps which the St. Lawrence River system takes from the level of Lake Superior to the Atlantic, there is a drop of 602 feet. The river drops 326 feet through the Welland Ship Canal and 225 feet from the level of Lake Ontario to Montreal.

## Works Required and in Hand

LACHINE SECTION

This section of the St. Lawrence Seaway extends from the Harbour of Montreal to the head of Lake St. Louis, some 31 miles. The drop in the level of water in this section is 50 feet and most of it is in the Lachine Rapids. It is possible to develop here 1,200,000 horsepower of electrical energy.

*Channel and Dyke*

The St. Lawrence Seaway Authority is building a 20-mile canal with considerable channel enlargement extending from deep water in Montreal Harbour to Lake St. Louis above Caughnawaga.

This canal entrance will be a short distance east of Jacques-Cartier Bridge, the Canal will follow the South Shore, partly in the Laprairie Basin and partly inland. There will be two locks; one at Victoria Bridge and one at Cote Ste. Catherine, opposite the Lachine Rapids. These locks will have the same dimensions as those already mentioned for the Welland Ship Canal. (The length available for ships is generally limited to 715 feet, the width 80 feet, depth over sills, 30 feet).

In 1947, a Board of Engineers was established by the Government of Canada to consider whether the scheme for the improvement of the Lachine Section as recommended by the Joint Board of Engineers in 1926 provided to the best advantage for such improvement and, if not, what alternative scheme it would recommend. The Board made public its report, which was widely circulated in 1948, and recommended to the Government two schemes for power and navigation and one scheme for navigation alone. The plan which The St. Lawrence Seaway Authority has adopted for the Lachine Section is the same in all respects as the one contained in the report of 1948 save and except that the canal is on the South side. In other words, under present plans, the canal— from Lachine Rapids to Montreal Harbour—is on the land side of the embankment in Laprairie Basin as well as from Victoria Bridge to the Harbour.

The principal reason for placing the canal on the South side around Laprairie Basin is that it would permit the extension of the Montreal Harbour to this area and create an important industrial area adjacent to Montreal. There are other important reasons for this change :

(*i*) It is easier to cope with both the present and future highway communications between Montreal and the South Shore under the proposed plan of development.

(*ii*) It avoids bringing the large Upper Lakers through St. Mary's current and the congested area of the Montreal Harbour.

(*iii*) Railway traffic conditions at Victoria Bridge are materially improved as compared with a railway-canal crossing at the Montreal end of that bridge.

*Modifications to Bridges*

Regulations provide that bridges across the Seaway shall have a minimum clearnace of 120 feet. Since the canal skirts the South Shore at Longueuil and the southerly spans of the Jacques Cartier Bridge did not provide such clearance, it was necessary to elevate the bridge. This is continuing.

Plans and designs were prepared for this work together with a modern approach to the bridge from the South. This work is being done in co-operation with the Quebec Highway department. Concurrently with this work, the National Harbours Board are proceedinsg with pla toe add an additional traffic lane on the downstream sde of the bridge. When these additions are completied,transportation facilities across Jacques Cartier Brndwigill be materially improved.

The matter of elevating Vietoria Bridge, however, is more complicated. This is a low-level bridge and to co-ordinate highway facilities with the rights of navigation presents a difficult problem. The St. Lambert Lock was built near its southerly end.

The bridge is the property of the Canadian National Railways. Their engineers and those of the St. Lawrence Seaway Authority have agreed upon a plan to provide maintenance of the normal flow of traffic. A lift span is being installed over the proposed canal and an added vehicular traffic lane was made available with the removal of tracks of the Montreal and Southern Counties Railway.

Use of the proposed canal embankment for a short distance will permit uninterrupted vehicular traffic across the seaway. The plan will be co-ordinated with plans for improvement of highway facilities across Victoria Bridge. A lift span at the upper end of the St. Lambert Lock will be lowered into place when the downstream span is lifted.

The southerly end of the Honore Mercier Bridge was elevated and a satisfactory approach to the bridge from the Caughnawaga side is being constructed. This will be done in co-operation with provincial highway authorities.

A moveable span is being installed in the Canadian Pacific Railway bridge at Caughnawaga.

It will be noted that the channel proceeds overland from the Cote Ste. Catherine Lock to by-pass the Lachine Rapids.

Turning basins are being constructed to allow ships, both deep-sea and lake carriers, to manoeuvre more freely in and out of the Lachine Section.

To provide 27 foot navigation to the head of Lake St. Louis the channel is being dredged through the lake from the end of the channel and dyke construction above Caughnawaga to the beginning of the Soulanges Section.

SOULANGES SECTION

The Soulanges Section extends from the head of Lake St. Louis to the foot of Lake St. Francis and is 16 miles in length. The total fall in this section is some 82 feet, which, it will be seen, is featured by the Cascades, Split Rock, Cedars and Coteau Rapids. To pass these, the Soulanges Canal now offers 14-foot navigation.

The new seaway, however, will make use of the Beauharnois Canal.

Power installations at the easterly end of the Beauharnois Canal must be by-passed, and here two locks

are being installed to lift vessels from Lake St. Louis to the level of the Beauharnois Canal. This canal was built with a plan to use it for navigation, if and when the 27 foot seaway plan should become a reality.

This canal is 16 miles long and is flanked by embankments about 3,300 feet apart.

The part of the canal which will be used for navigation is presently crossed by two combined highway and railway bridges consisting of fixed spans. The parts of the substructures of these two bridges adjacent to the navigation portion of the canal are built to provide for the future installation of vertical lift bridges which will provide a clear horizontal width of 200 feet and a vertical clearance of 120 feet.

Modifications to one other bridge must be made to provide for traffic over the canal; and a four-lane highway tunnel was constructed to carry traffic beneath the cannel from one side to the other.

LAKE ST. FRANCIS SECTION

This section, which lies wholly in Canada, is 29 miles long. It is a widening in the St. Lawrence River, has an area of about 90 square miles and has a total drop from one end to the other of about one foot.

To provide 27-foot navigation in this section, dredging of shoal areas over the proposed seaway course is all that is required.

INTERNATIONAL RAPIDS SECTION

The International Rapids Section, extending from the Western end of Lake St. Francis to Chimney Point, four miles East of Prescott, Ontario, is 47 miles long with a total difference of water level of 92 feet.

In this section just West of Cornwall are located the power houses capable of developing 2,200,000 horsepower of electricity built by the Hydro-Electric Power Commission of Ontario and the Power Authority of the State of New York. The main power features are :

1. A dam below the Long Sault Rapids from the American mainland to the head of Barnhart Island, and two powerhouses, (divided only by the international boundary line) from the foot of Barnhart Island to the Canadian mainland just above Cornwall, Ontario.
2. An upper control dam in the vicinity of Iroquois Point.
3. Dykes, where necessary, to retain the pool level and reduce flooding.
4. The relocation of highways.
5. The relocation of railways.
6. Extensive channel enlargements.

Thus will be created an artificial "Seaway Lake", some thirty miles in length and from one and a half to four miles in width.

The essential navigation works consist of two canals, one on Canadian territory at Iroquois, with one lock to by-pass the control dam, the other on American territory opposite Cornwall with two locks to by-pass the main dam and powerhouses.

The St. Lawrence Seaway Authority has built the lock and canal at Iroquois, and the Saint Lawrence Seaway Development Corporation has built canal and two locks (one at Grasse River and the other at Robinson Bay) on the American side.

Thus, navigation proceeding upstream from Lake St. Francis will enter the Snell Lock at Grasse River on the American side, transit the Long Sault Canal and enter the power pool at the Eisenhower Lock. It will proceed by the indicated channel to the Iroquois Lock on the Canadian side and by that lock and its canal be lifted to the water level of the Thousand Islands Section and proceed by dredged channels into Lake Ontario.

Scheduled to be in use for the opening of navigation in the spring of 1959, the Seaway will become a major achievement in the history of both Canadian and United States transportation. The St. Lawrence Seaway Authority, in conjunction with its counterpart, the Saint Lawrence Seaway Development Corporation, will soon bring this long awaited dream to realization.

## STUDY OF RIVER TRAINING WORKS

The Railway Board has ordered a comprehensive expert study to be undertaken in the advances made in recent years in the science of river training. The results of such a study it is felt, will be of immense practical advantage, not only to the Railways but also to other public authorities in the country concerned with river works.

The Indian Railways have been pioneers in the training of a large number of rivers, and Railway engineers have made momentous contributions in this field. Works published by some of them decades ago are still regarded as authoritative documents on the subject of river training.

However, as the hydraulic science and techincal knowledge in this sphere have since advanced considerably, and as the Indian railways spend large sums of money on the construction and maintenance of river training works, it has been considered necessary that uptodate data should be collected and analysed, difficulties investigated and conclusions recorded for further guidance, in the light of experiences gained in the country as a whole, and specially on the railways. The recording of these conclusions may take the form of bringing the previous valuable works on the subject uptodate.

Shri H. K. L. Sethi, General Manager and Chief Engineeer of the Ganga Bridge Project, and an engineer of 34 years' standing, has been entrusted with this task. Shri Sethi will include in his study not only the problem of large rivers in alluvium, but also of streams in the sub-montane regions.

A bibliography of important books consulted in the course of the study will be compiled, and an appreciation would be prepared of the model studies so far conducted at hydraulic laboratories in the country.

# Power from Kariba

**The Kariba project is of great importance to A.E.I. as BTH and M-V have received orders worth nearly £4,000,000. M-V are supplying all the generators for the first stage of the scheme. The contract is worth one and three-quarters million pounds and the generators each weighing about 720 tons, will be amongst the largest of their type in the world.**
**BTH have a contract worth over two million pounds to supply all the 330 kV switchgear covering six complete substations at Kariba, Kitwe, Norton, Sherwood, Salisbury and Bulawayo.**

The giant hydro-electric scheme at Kariba in the heart of Rhodesia would stretch and test the resources of a mature, well-developed industrial country. In a young and relatively under-developed country populated by 7m. Africans and fewer then 300,000 Europeans, it is a symbol of Rhodesia's unbounded confidence in its mineral and industrial potentialities

Harnessing the waters of the mighty, often intractable, Zambesi River is to achieved by erecting a dam 400 feet high between the towering banks of the Kariba Gorge and by carving inside the rock banks of the river two immense underground caverns which will house the generating equipment. On completion of Stage I of the project by 1960, these halls will house six generating sets with a total capacity of 600 mW. Capital expenditure of Kariba will then have reached about £80m.

Subsequently, during Stage II of the scheme, up to seven additional generators of 100 mW. capacity each will be installed, bringing total generating capacity up to 1,300 mW. and total capital outlays to around £114m. The whole project will be completed by 1971 or 1972.

Kariba is based on careful estimates of the Federations, future power demands. These indicate that the present demand amounting to 350 mW. will be doubled to 700 mW. by 1961 and at least doubled again to 1,400 mW. by 1971. Much of the additional demand will arise in the Copperbelt, the economic backbone of the Federation. But there is also a solid expectation of greater power requirements for the mining and processing of Rhodesia's many other minerals and for the development of secondary industry where growth prospects are good.

A visit to Kariba, now that the main dam in taking shape, is an exhilarating and impressive experience. Kariba, located in a wild and undeveloped territory, has been transformed in the past year or so into a lively township housing over 1,000 Europeans and 6,000 Africans, equipped with clubs, canteens, cinemas, shops, banks, schools, a modern hospital, a swimming-pool and so on. The whole area is a scene of feverish activity. Everyone I met displayed a conscious pride in his association with Kariba and immense eagerness to maintain the remarkable momentum which the whold project has already achieved.

On all sides I heard nothing but praise for the achevements of the Italian contractors, Impresit, who secured the main civil engineering contract for the dam and underground power station halls. Despite the setback caused by the flooding of coffer dam on the left bank of the Zambesi, construction of the half-section of the main dam inside this coffer dam to a height of 80 feet was completed on schedule by the end of June, thus winning for Impresit a bonus of £150,000.

The next stage is the construction of a circular coffer dam on the right flank of the river inside which the other half of the main dam will be erected. Towards the end of 1958, the base of the main dam should be complete up to a height of 80 feet and water will then begin to be impounded in the reservoir behind the dam. The most tricky parts of the operation will then have been completed. Thereafter there will remain the relatively simple though mammoth task of pouring into the dam over 3,000 tons concrete a day for two years until the dam reaches its full height of 400 feet in 1960.

Given average rainfall, the reservoir behind the dam should be full by 1963. Rhodesia will then be the proud possessor of the largest man-made lake in the world. It will extend about 160 miles upstream with a maximum width of 30 miles and an average width of 12 miles. The total quantity of water stored will be about 4½ times the capacity of the Hoover Dam, which is at present the world's largest man-made reservoir.

Apart from the huge power supplies which are Kariba's primary purpose, important subsidiary benefits will be irrigation schemes to aid agricultural development, a large fishing industry in Kariba Lake yielding probably 20,000 tons of fish a year, and the prospect of establishing round the shores of the lake a number of attractive tourist resorts.

On the other hand, the project raises an expensive

[*Continued on page* 32

# Prospects of Electricity Development in Europe

Every two years, the Electricity Committee of the O.E.E.C. analyses the situation of the European electricity supply industry in a general report. These reports provide an opportunity for a thorough discussion of the main problems affecting the industry. In 1955, for instance, the economic factors influencing the development of nuclear energy were discussed, whilst the present report lays special stress on the long-term outlook up to 1975.

The report is divided into five parts : Parts I and II deal with the present situation of the industry ; Part III discusses the medium-term prospects and the difficulties confronting the development of the industry, and Part IV touches upon the long-term prospects. The last pages are devoted to a review of the Committee's principal activities in 1956 and the part played by it with regard to international co-operation.

The statistical data and the medium and long-term estimates used for compiling this report were supplied by the countries concerned. All this information is reproduced in an appendix containing seven series of tables on the following subjects : plant capacity, maximum available capacity, output of public utilities and autoproducers, distribution of consumption by sectors and fuel consumption in power stations. Until this year it had not been possible to give an analysis of the production and consumption of autoproducers, but thanks to the work achieved by the International Federation of Industrial Autoproducers and Consumers of Electricity (FIPACE), which now publishes an annual Statistical Bulletin, detailed figures have been obtained for most countries.

This report shows that the electricity supply industry has continued to expand at a yearly rate of about 8 per cent in 1956, and has reached twice the level of production of 1948. No increase on this scale had ever been recorded over so long a period in the past.

To meet an ever-increasing demand, the electricity undertakings in the O.E.E.C. area have launched investment programmes based on an average increase in consumption of 7 per cent per year for the next five years. Most of them, however, fear that they will be unable to carry out these programmes entirely owing to the difficulties encountered by electricity producers in raising the necessary funds. Rising interest rates on the money market, combined with the often very stringent price controls imposed by governments, are the two difficulties most frequently mentioned.

These circumstances make increases in electricity rates likely. Any increase should, however be slight, owing to constant improvements which reduce the cost of equipment in terms of real value and which save fuel.

The member countries have also given some guidance on the long-term trend of electricity requirements and on how these requirements may be met. According to their forecasts, consumption might be roughly three and a half times larger in twenty years' time.

That period will witness a gradual tailing off in the development of hydro resources owing to the exhaustion of the more profitable sites, whilst nuclear energy will be beginning to develop on a big scale. The rate of expansion of nuclear production will depend on technical and economic factors which are still uncertain ; the first estimates made by the countries show that 30 to 35 per cent of the total thermal energy produced in Europe might be of nuclear origin by 1975 and this would mean a fuel saving of about 120 million tons in terms of coal equivalent. The achievement of these aims will also depend on whether the capital required can be raised on reasonable terms.

It is interesting to note that the degree of international co-operation in this field of electricity development is increasing in the area. For example exchange of technical information and contacts between engineers arranged by various international associations are numerous and have greatly benefited every participating country. Standardization of equipment has been carried to considerable lengths. Adoption of 220 kV and 380 kV for long distance transmission by all the countries concerned has made it possible to build up a genuine international grid which is developing further.

Power transfers across national frontiers in Europe will now amount to 3 and 4 per cent of the total consumption. This is likely to go up pretty quickly. An international mission of experts have gathered the impression, after a European tour of generating and transmission installations, that a close operation coordination will yield maximum benefits when every country has been able to bring its national generating equipments into line with the most recent technique.

One natural reaction to the study of the report is that such a framework of developing international co-operation would be exceedingly useful in the underdeveloped areas served by the ECAFE. Here hydroelectric potentialities are very great and these could be usefully developed for utilisation in regions which may politically come under States different from the one where the generation takes place. Afghanistan, Pakistan, India and Burma obviously come to mind.

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**Power from Kariba**

and tricky problem in the resettlement of the 25,000 primitive Batonga tribesmen living in the area to be flooded. This problem, whose solution involeves an expenditure of £2m. or more is being tackled with the utmost care and sympathy. Already 5,000 people have moved to other areas and plans for resettling the remaining 20,000 are actively in train. By way of compensation, the Batonga are given two years' freedom from taxation, six months' free food, and substantial personal compensation totalling in all about £320,000

Some Rhodesians whom I met tended to question the wisdom of Kariba, and seemed to feel that it was too grandiose and unrealistic. They felt that a less ambitious project coupled with greater concentration on communications would produce a better-balanced pattern of development of Federal resources. But I thought that the enthusiasts for the scheme, very easily a majority, made out a better case.

The biggest present and prospective power consumer in the Federation is the Copperbelt. A dominant element in the economy, it accounts directly for a quarter of the national income, about three-fifths of the exports, and one-third of Government tax revenues. Copperbelt expansion already strains available power resources. The further growth projected beyond 1960 will be feasible only on the basis of large additional power supplies at reasonable prices. These Kariba will supply, and more economically than thermal stations.

At the moment the Copperbelt survives in power terms with Wankie coal, power imported from Le Marinal hydro-electric station in the Congo, imported oil and locally cut wood. Without the prospect of Kariba power in 1960, the Copperbelt would need to set its sights considerably lower.

Moreover, the Federation is anxious to diversify its economy and reduce its dependence on copper. To attract secondary industry, it must give potential investors the assurance of adequate power supplies. The power available when Stage I at Kariba is completed in 1960 will be absorbed easily. Subsequent additions to capacity during Stage II can be planned reasonably flexibly in accordance with demand trends, the objective being to ensure that no enterprise is deterred from setting up new business or extending existing one through anxiety about power supplies.

When Kariba matures, moreover, the burden borne by the railways in transporting coal to the Copperbelt will be lightened and subtantial quantities of coal may well be available for export. As the Federal Minister of Power, Sir Malcolm Barrow, has said: "From 1960 onwards the supply of power from Kariba will avoid the further investment in coal mining, railway transport and water supplies which would otherwise be necessary to expand production of electricity from thermal stations. This should be a very great relief to the claim for investment in basic services."

Kariba power will be cheap power. According to Mr. Duncan Anderson, chairman of the Federal Power Board, the cost of Kariba power is estimated at 0. 869d. a unit in 1961, 0. 588d. in 1962, decreasing steadily to 0.283d. in 1972. This compares with thermal power's present cost of 0.728d. a unit, a figure likely to be increased over coming years through wage and other cost increases in the coal industry and on the railways. Mr. Anderson estimates that by 1971 Kariba power will be about £10m. a year cheaper than equivalent power derived from thermal stations.

Selling prices, as opposed to costs, are another matter They will depend on the terms on which finance is arranged and the period of amortisation of loans. But the best opinion possible at this stage is that Kariba will achieve its main objective of meeting all probable energy requirements in the Federation for years to come at reasonable prices. Kariba is based on the belief that the Federation in the next decade can maintain the growth tempo of the past decade. Kariba, in fact, is an indispensable pre-condition for the maintenance of that tempo.

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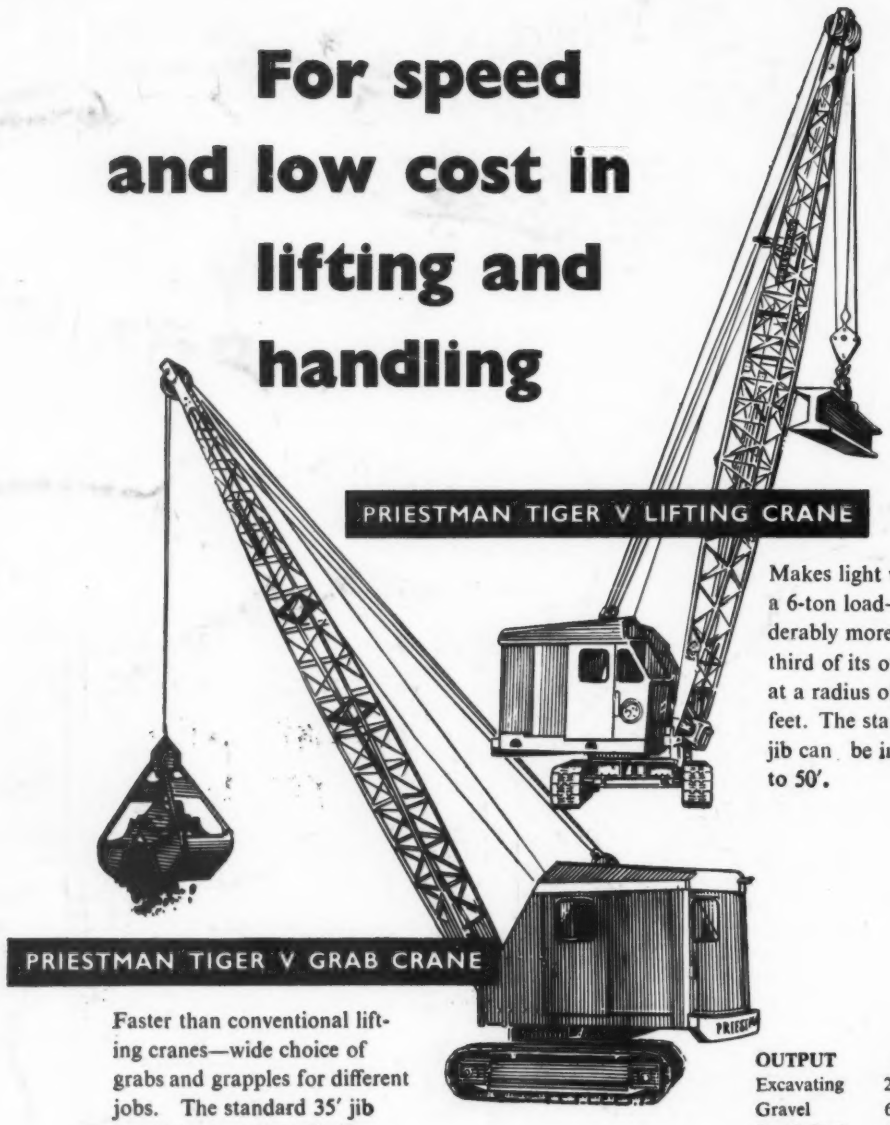

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